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Owing to the General Strike The Engineer was not published on May 7th and 14th.

The Engineer

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PUBLIC NOTICES

G.I.P. RLY. ELECTRIFICATION.

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
APPROXIMATELY 70,000 COPPER BONDS for TRACK RAILS.
Tenders due on Tuesday, 15th June, 1926, before 2 p.m.
Specification and forms of Tender obtainable from the above at a fee of 5s. each, which will not be returned. 2402

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
1. GALVANISED CORRUGATED STEEL SHEETS.
2. DIVISION PLATES for I.R. SPRINGS.
3. INDIA-RUBBER SPRINGS.
4. POINT RODDING.
5. BOILERS FOR LOCOMOTIVES.
6. VACUUM BRAKE GEAR and RIGGING.
7. BUFFERS, &c., for RAILWAY STOCK.
8. BRIDGE WORK.
Tenders due on the 4th June, 1926, for No. 1, on the 8th June, 1926, for Nos. 2, 3 and 4, on the 11th June, 1926, for No. 5, on the 15th June, 1926, for Nos. 6 and 7, and on the 18th June, 1926 for No. 8.
Tender forms obtainable from the above. 2407

Pumping Set, Consisting of Simpson (Newark) Centrifugal Pump, having an output of from 200 to 300 gallons per min. against 150ft. head, direct coupled on combination bed-plate to Rhodes single-phase Repulsion Motor, 28 H.P., 250 volts, 1540 r.p.m., 50 cycles per sec., with starter. Pump believed to be in running order, motor requires repair. Applications for forms of Tender should reach the SUPERINTENDING ENGINEER, N.W. District, W. and B. Dept., R.A.F. Depot, Uxbridge, Middx., not later than 4th June, 1926. 2370

Assistant Engineer Required by the GOVERNMENT of PALESTINE for the PUBLIC WORKS DEPARTMENT: three years' service, with prospect of permanency. Salary £E400-25-500 a year plus £E50 expatriation allowance and in addition a temporary and variable cost of living allowance of 5 per cent. on minimum salary of grade plus £E27. Free passages. Candidates, unmarried, age 25-35, should have been trained in the Municipal Engineer's Office and should have had considerable outside experience on the construction of roads and buildings and should be competent to take charge of such works without trained assistance. Preference given to candidates holding the A.M.I.C.E. qualification.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14573. 2374

Assistant Engineers (3) REQUIRED for the NIGERIAN GOVERNMENT RAILWAY (Construction) for a tour of 12 to 18 months, with possible extension. Free passages and a commuted bush and travelling allowance of £9 a month whilst on duty in the Colony. Camp equipment provided. Outfit allowance of £60 on first appointment. Liberal leave on full salary. Salary £480 for the first three years of service, then £510, rising to £720 a year, by annual increments of £30, and thence rising to £920 a year by annual increments of £40. Candidates must have passed examination to qualify for A.M.I.C.E. or hold equivalent professional qualifications and possess experience on Railway Location.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, clearly quoting M/14155. 2372

Assistant Engineers (8) REQUIRED for the PUBLIC WORKS DEPARTMENT of the FEDERATED MALAY STATES for four years' service. Salary 400 dollars a month, rising to 800 dollars by annual increments of 25 dollars, plus a temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax at present imposed by the Federated Malay States Government. Free passages provided. Candidates, age 23 to 26, preferably unmarried, must have received a good theoretical training, preferably at a University or College recognised by the Institution of Civil Engineers and possess a Civil Engineering Degree or obtained such other diplomas or distinction in engineering as the Secretary of State may decide in any particular case, or have completed articles with a Civil Engineer of good standing and have passed the examination for Associate Membership of the Institution of Civil Engineers. In addition, candidates must have had at least one year's practical experience of civil engineering under a qualified civil engineer.—Apply at once by letter, giving brief details of qualifications and experience and stating age and whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting clearly at head of application M/14378. 2326

Civil Service Commission.
VACANCIES FOR CIVIL ENGINEERS IN CONNECTION WITH THE HYDRO-ELECTRICAL DEVELOPMENT OF THE RIVER SHANNON.
APPLICATIONS are INVITED from competent Civil Engineers for the following POSTS on the Civil Constructional Staff for the above scheme :—
TWO SENIOR ASSISTANT ENGINEERS.
Inclusive salary £500 per annum, with possible increase to £600 per annum.
Candidates must hold a degree of Civil Engineering or its equivalent.
The appointment will be made by the Minister for Industry and Commerce on the recommendation of the Civil Service Commissioners, who will investigate the qualifications of candidates with the assistance of a Board of Selection set up by the Commissioners. Applicants may be required to attend in person before the Board, and the successful candidates may be required to undergo a medical examination. A preference will be given to ex-National Army candidates. etc.
Further particulars and forms of application may be obtained on a request in writing addressed to the SECRETARY, Civil Service Commission, 35, St. Stephen's Green, Dublin.
Completed forms of application will be received up to but not after the first post on 28th May, 1926. 2358

Draughtsman Required for the PUBLIC WORKS DEPARTMENT of KENYA COLONY for a tour of 30 months' service. Salary £400, rising to £500 a year by annual increments of £20, plus a temporary local allowance of 20 per cent. at present authorised up to the 30th June, when its continuance or otherwise will be subject to review. Outfit allowance of £30 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, 25-35 years of age, must be thoroughly trained and experienced in the design of buildings and be competent to prepare working drawings rapidly and efficiently of large buildings from sketches.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14371. 2340

Royal Corps of Naval CONSTRUCTORS.
A COMPETITIVE EXAMINATION for a POST of PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, in June next.
The Regulations and full particulars of the salary, &c., may be obtained from the SECRETARY of the ADMIRALTY (C.E. Branch), Whitehall, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than the 12th May next.
Candidates must be not more than 24 years of age on the 1st October next.
PRIVATE STUDENTS OF NAVAL ARCHITECTURE.
In conjunction with the above Examination there will be a QUALIFYING EXAMINATION for the admission of PRIVATE STUDENTS of NAVAL ARCHITECTURE to the Royal Naval College, Greenwich.
Applications for the Regulations, &c., should be made as in the case of the Examination for the post of Probationary Assistant Constructor (see above).
Private Students are required to pay a fee of £50 a Session whilst at the College. 2363

Structural Engineer Required by the GOVERNMENT of KENYA COLONY for a tour of 30 months' service. Salary £800 a year. Free quarters and passages and liberal leave on full salary. Candidates, aged 30 to 40, must possess the Fellowship Diploma of the Surveyors' Institution (Structural and Sanitation Section), or hold equivalent professional qualifications. Must be expert in designing all forms of building construction, including constructional steel work, reinforced concrete and sanitation, in collaboration with architects.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14433. 2371

Government of Bengal. APPLICATIONS are INVITED for an APPOINTMENT of EXECUTIVE ENGINEER, Electrical Division, Public Works Department. Candidates must have at least three years' practical experience in an Electrical or Mechanical Engineering Workshop or Electric Power Station and subsequently at least five years' regular practice of Electrical Engineering. Sound theoretical knowledge of Electrical Engineering essential. A Degree in Electrical Engineering and a knowledge of accounts will be an advantage. Age 30-40 years.
Forms of application and further particulars should be obtained from the SECRETARY to the HIGH COMMISSIONER for INDIA, 42, Grosvenor-gardens, London, S.W. 1. Last date for receipt of applications the 7th June, 1926. 2390

Inspector of Machinery REQUIRED for the Engineer's Department of the City Council, GIBRALTAR. Salary £340 a year, rising to £320 a year by annual increments of £12. Free quarters and second-class passage. Half-pay during period of voyage. The appointment is absolutely terminable by one month's notice on either side and is held during the pleasure of the Council, who has power, with the Governor's approval, to grant superannuation allowances. Candidates must have had a proper workshop training, have satisfactorily held responsible positions and possess a superior and sound general knowledge of the care and maintenance of all classes of municipal machinery and plant, more particularly of steam engines, pumps, boilers and pumping machinery. Preference will be given to those holding a First Class Board of Trade Certificate or those of similar standing from the engineering branch of the Navy. Applications must be in the applicants' own handwriting and should state in detail where they have received their practical training and gained their experience, the nature and size of their previous posts and degree of responsibility attached to them. They must also state their age and, if married, particulars of their family; and copies of three recent testimonials should be attached together with the names of two responsible persons in a position to give general references if necessary.—Applications should be addressed to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14583. The Crown Agents will forward the applications to the City Council of Gibraltar, who will make the selection. The Crown Agents will not communicate with any candidate unless requested by the City Council to do so. 2404

PUBLIC NOTICES

Technical Officers, Grade II., are REQUIRED at the Royal Aircraft Establishment for writing technical descriptive matter and instructional handbooks on (1) Aircraft and Aircraft Equipment, (2) Aero Engines and Aero Engine Accessories. Applicants must have engineering knowledge and experience and a capacity for clear expression in good English. Some experience in writing for publication is desirable. Ex-Service men preferred. Commencing salary £250 a year plus Civil Service bonus (giving a present total of £377) on the scale £250-20-350 a year plus bonus.
Applications should be made on form to be obtained from the SUPERINTENDENT, R.A.E.S., Farnborough, Hants. When writing please quote A. 113. 2376

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.
Principal: B. MOUAT JONES, D.S.O., M.A. (Oxon).
UNIVERSITY OF MANCHESTER (FACULTY OF TECHNOLOGY).
DEGREE COURSES IN TECHNOLOGY.
The Prospectus gives particulars of the courses leading to the Manchester University Degrees (B.Sc. Tech., M.Sc. Tech., and Ph.D.) in the Faculty of Technology, in the following Departments :—
MECHANICAL ENGINEERING (Prof. G. G. Stoney, D.Sc., F.R.S.).
ELECTRICAL ENGINEERING (Prof. Miles Walker, M.A., D.Sc.).
MUNICIPAL AND SANITARY ENGINEERING (C. S. Colemas, D.Sc.).
CHEMICAL TECHNOLOGY, including General Chemical Technology, Chemistry of Textiles (Bleaching, Dyeing, Printing and Finishing), Paper Manufacture, Metallurgy and Assaying, Chemical Technology of Brewing, Electro-Chemistry, Colouring Matters, Foodstuffs and Fuels (Prof. F. L. Pyman, D.Sc., F.R.S.).
TEXTILE TECHNOLOGY (Prof. W. E. Morton, M.Sc. Tech.).
PHOTOGRAPHIC TECHNOLOGY (C. W. Gamble, O.B.E., M.Sc. Tech.).
Prospectus will be forwarded free on application to the REGISTRAR, College of Technology, Manchester. 2334

City of Cardiff Education Committee.
THE TECHNICAL COLLEGE.
Principal - CHARLES COLES, B.Sc. (Lond.).
The SERVICES will be REQUIRED in September next of a Full-time ASSISTANT LECTURER in ENGINEERING, qualified to teach up to Honours B.Sc. standard. The main subjects required will be those of Mechanical and Civil Engineering, but a good knowledge of Electrical Engineering will be a recommendation.
Salary payable according to Burnham Award, Scale III.
Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the Principal (from whom further particulars may be obtained) on or before Saturday, 5th June.
The successful candidate will be required to pass a medical examination by the Authority's Medical Examiner for Teachers at Cardiff before commencing duties, and to contribute under the School Teachers (Superannuation) Acts.
JOHN J. JACKSON, Director of Education.
City Hall, Cardiff. 2375

The Polytechnic, Regent STREET, W. 1.
SCHOOL OF ENGINEERING.
WANTED, to commence in September next, an ASSISTANT FULL-TIME LECTURER in MECHANICAL and STRUCTURAL ENGINEERING. Good academic qualifications and practical experience are essential. Salary in accordance with the Burnham Scale for technical teachers and resolutions thereon by the London County Council.
Applications should be made on special form (send stamped and addressed envelope) to the DIRECTOR OF EDUCATION on or before June 7th. 2361

University of Glasgow.
LOUDON LECTURESHIP IN ENGINEERING PRODUCTION.
The first APPOINTMENT to the LECTURESHIP will be made shortly by the University Court, and will be for a term of three years. The Lectureship is a part-time appointment, and the Lecturer will give during each winter session a course of forty class lectures and five public lectures on "Machine Tool Types, the Art of Cutting Metals and the Methods of Production."
Applications should be made by 5th June to the SECRETARY, University Court, University of Glasgow, from whom further information may be obtained. 2411

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PUBLIC NOTICES

Derby Technical College.

APPLICATIONS are INVITED for the POST of PRINCIPAL. Commencing salary £800 per annum. Particulars from the undersigned.

F. C. SMITHARD,
Secretary to the Derby Education Committee.
Education Offices,
Becket-street, Derby
May 3rd, 1926. 2342

Loughborough College.

DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING.

The Governors invite APPLICATIONS for the POST of ASSISTANT in the above Department.

Salary in accordance with the Burnham Scale. Extra remuneration, according to the College Scale will be given if evening lecturing is taken, although this is quite optional.

Full particulars of the appointment and forms of application can be obtained from the REGISTRAR, to whom applicattons should be forwarded not later than the 22nd May. 2348

Royal State Railways of Siam.

NOTICE.

Sealed TENDERS for the SUPPLY of SUPERSTRUCTURES of STEEL RAILWAY BRIDGES, B.E. 2469, will be received by the Administration of the Royal State Railways of Siam, Bangkok, until Fourteen o'clock on the 15th September, 1926, at which place and hour the tenders will be publicly opened and read.

Blank Tender forms, general conditions, specifications and drawings may be obtained from Messrs. C. P. SANDBERG, 40, Grosvenor-gardens, London, S.W. 1, upon payment of £1 10s. per set, which sum will not be refunded.

The Right is reserved to reject any or all Tenders, and to accept any Tender which is to the best interests of the Royal State Railways of Siam. 2422

Belper Urban District Council.

WATERWORKS EXTENSION.

The Belper Urban Council invite TENDERS from experienced firms of Boring Contractors for PUTTING DOWN a 24in. BORE-HOLE at their Waterworks at Belper to the depth of 175ft. and LINING with STEEL TUBES.

Copies of the specification may be obtained from the Council's Consulting Engineers, Messrs. G. and F. W. Hodson, Bank Chambers, Loughborough, on deposit of cheque for Five Guineas, which will be refunded to bona fide tenderers on return of the papers.

Tenders are to be sent to the undersigned not later than 12th June, 1926.

The lowest or any Tender not necessarily accepted.

Dated this 17th day of May, 1926.

J. PERCY R. PYM,
Clerk to the Council.
Council Offices, Belper. 2403

Bombay, Baroda and Central India Railway.

The Directors are prepared to receive up to Noon on Wednesday, 9th June, TENDERS for the SUPPLY of—

1. STEEL SLEEPERS.
2. STEEL SLEEPER KEYS.
3. STEEL DISTANCE PIECES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of £1 each for Nos. 1 and 2, and 10s. each for No. 3 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France, S.W. 1,
17th May, 1926. 2380

Borough of Ryde.

DISPOSAL OF PLANT.

The above Council invite OFFERS for the undermentioned PLANT, which can be inspected at the Corporation Waterworks, Knighton, near Newchurch, I.W., by arrangement with the undersigned:—

(1) One 12 H.P. Portable Engine, Davey, Paxman, 1918, first-class condition.
(2) One 14 H.P. Portable Engine, Garrett and Sons, 1924, as new.
(3) Two 8in. by 6in. Double-cylinder Steam Winding Winches, good condition.
(4) One Complete Hardy Type A Air Compressing Set and Four Hammer Drills and Accessories, first-class condition.
(5) Three Engine Belts.
(6) 560 Yards Lineal "Jubilee" Rail Track, 24in. gauge in 10ft. 6in. lengths.
(7) Four Sets of Points and One Turntable.
(8) Four Tipping Wagons.
(9) Three Tipping Skips.

Sealed Offers, endorsed "Plant," are to be delivered to me not later than Twelve o'clock midday on Tuesday, the 25th May, 1926.

The Council do not bind themselves to accept the highest or any Tender.

B. F. HOLNESS, M. Inst. M. and Cy. E.,
Borough Engineer.
Town Hall, Ryde, I.W.,
30th April, 1926. 2352

City and County of Kingston-upon-Hull.

ELECTRICITY DEPARTMENT.

The Electricity Committee of the Hull Corporation invite TENDERS for :—

TEN 12-TON MINERAL WAGONS.

Tender form, general conditions and specification can be obtained on payment of £1 1s. to the City Treasurer, Guildhall, Hull, such deposit being returnable on receipt of a bona fide Tender.

The Corporation does not bind itself to accept the lowest or any Tender.

Tenders, addressed "Chairman, Electricity Committee, Guildhall, Hull," and endorsed "Tender for Wagons," should be delivered by Noon on Thursday, 20th May, 1926.

H. BELL, M.I.E.E.,
City Electrical Engineer and Manager.
Electricity Works,
Sculcoates, Hull. 2337

City of Birmingham Water Department.

The Water Committee of the Corporation of the City of Birmingham is prepared to receive TENDERS from competent firms for the MANUFACTURE and DELIVERY of 42in. diameter SOCKET and SPIGOT STEEL PIPES lined centrifugally with concrete, together with the necessary SPECIALS, for portions of the Third Main on the Elan Aqueduct situated (Contract 18, about 1900 lineal yards) on the Severn Siphon between Hagley and Kidderminster, and (Contract 19, about 1700 lineal yards) on the Downton Siphon in the neighbourhood of Knighton.

Specifications and forms of Tender may be obtained from the Secretary of the Water Department, Council House, Edmund-street, Birmingham, on payment of the sum of One Guinea in respect of each of the two proposed contracts. The amount deposited will be refunded on receipt of a bona fide Tender.

Sealed Tenders, on the forms provided for the purpose, addressed to "The Secretary, Water Department, Council House, Birmingham," and endorsed "Contracts 18 and 19, Steel Pipes," should be delivered at the Secretary's office on or before 10 a.m. on Thursday, 10th June, 1926.

The Water Committee does not bind itself to accept the lowest or any Tender.

F. W. MACAULAY, M. Inst. C.E.,
Chief Engineer.
J. H. BROADLEY, F.C.I.S.,
Secretary.
Water Department,
Council House, Birmingham,
13th May, 1926. 2419

PUBLIC NOTICES

AMENDED ADVERTISEMENT.

City of Nottingham.

TO BUILDERS AND CONTRACTORS.
NORTH WILFORD POWER STATION.
CONTRACT NO. 11.—EXTENSION NO. 1.

The Electricity Committee is prepared to receive TENDERS for the ERECTION of BUILDINGS in connection with Extension No. 1 of this station.

Drawings may be seen and copies of the general conditions of contract, specification, bill of quantities, and form of Tender may be obtained on application to Mr. T. Wallis Gordon, City Engineer and Surveyor, Guildhall, Nottingham, on payment of a deposit of Two Pounds, which will be returned on receipt of a bona fide Tender.

Sealed Tenders are to be delivered to the undersigned in the official envelope provided not later than 9 a.m. on Tuesday, 8th June, 1926.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be accepted from firms who conform to the conditions of the contract as regards paying the local standard rate of wages, &c., and to the working rules of the Nottingham district.

By Order,
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham,
13th May, 1926. 2365

AMENDED ADVERTISEMENT.

City of Nottingham.

TO STRUCTURAL ENGINEERS.
NORTH WILFORD POWER STATION.
CONTRACT NO. 12.—EXTENSION NO. 1.

The Electricity Committee is prepared to receive TENDERS for about :—

420 TONS of STEEL WORK in Stanchions, Girders, Beams, Roof Trusses, &c.

2 TONS of CAST IRON in Gutters, Standards, &c., required in connection with Extension No. 1 of this station.

Drawings may be seen and copies of the general conditions of contract, bill of quantities, specification, and form of Tender may be obtained on application to Mr. T. Wallis Gordon, City Engineer and Surveyor, Guildhall, Nottingham, on payment of a deposit of Two Pounds, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, duly stating the time required for the completion of the work, are to be delivered to the undersigned in the official envelope provided, not later than 9 a.m. on Tuesday, 8th June, 1926.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be accepted from firms who conform to the conditions of the contract as regards paying the local standard rate of wages, &c., and to the working rules of the Nottingham district.

By Order,
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham,
13th May, 1926. 2366

City of Bradford.

SEWAGE DEPARTMENT.
SURPLUS PLANT FOR DISPOSAL.

ONE "Ruston" No. 15 STEAM CRANE NAVVY, 2 c.y. bucket, 4ft. 8½in. gauge.

50 (about) "Hudson's" 20 c.f., 2ft. gauge, "U" shape TIPPING WAGONS.

3 OPEN-TOP PRESSED STEEL TANKS, 140ft. by 48ft. by 12ft. high.

One 50 B.H.P. SEMI-DIESEL OIL ENGINE, by Robson.

One 10/20 H.P. "Titan" TRACTOR, by the International Harvester Corporation, Chicago.

The above plant has been little used, and is in excellent condition, and may be inspected at the Esholt Sewage Disposal Works (station, Apperley Bridge and Rawdon, L.M. & S.).

Further particulars may be obtained from, and offers to be submitted to, the SEWAGE WORKS ENGINEER, Esholt Hall, near Shipley.
10th May, 1926. 2367

City of Wakefield Waterworks.

RYBURN SCHEME.
CONTRACT No. 5.—PIPE LAYING.

The Corporation invite TENDERS for LAYING about 18 Miles of CAST IRON and STEEL PIPES, 22in. and 20in. in diameter, between Barkisland and Ardsley, including the Crossing of Railways, Canals, Rivers and other incidental works. The pipes, valves and castings will be provided by the Corporation.

Forms of Tender, conditions of contract, specification, quantities and other particulars may be obtained from, and drawings may be seen at the office of Mr. C. Clemesha Smith, M. Inst. C.E., Waterworks Engineer, Town Hall, Wakefield, on and after Friday, 21st May, 1926 (except on Whit Monday and Tuesday), on payment of a deposit of Two Guineas, which will be returned on receipt of a bona fide Tender and the documents supplied.

The Corporation do not bind themselves to accept the lowest or any Tender.

Tenders, endorsed "Pipe Laying," to be delivered to me not later than Noon on Monday, 14th June, 1926.

A. C. ALLIBONE,
Town Clerk.
Town Hall, Wakefield,
15th May, 1926. 2362

County Borough of Croydon.

SOUTH NORWOOD BATHS.
FILTRATION PLANT.

Notice is hereby given that the Council are prepared to receive TENDERS for the SUPPLY and ERECTION of a complete FILTRATION PLANT for treating the water in two Swimming Ponds at the South Norwood Baths.

Specification, conditions and form of Tender may be obtained on application at the office of the Borough Engineer, Town Hall, Croydon, upon payment of a deposit of One Guinea, which will be returned upon receipt of a bona fide Tender.

Tenders, on the prescribed form, to be sent to me by Eleven o'clock in the forenoon of Monday, 28th June, 1926, endorsed "Tender for Filtration Plant, South Norwood Baths."

Tenders will only be received subject to the draft contract, specification, and conditions, deposited at my office, and which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

J. M. NEWNHAM,
Town Clerk.
Town Hall, Croydon,
May 18th, 1926. 2397

The South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. PRESSED STEEL SLEEPERS.
2. STEEL BEARING PLATES for F.B. RAILS.
3. STEEL TYRES for LOCO. ENGINES and TENDERS.
4. FISH BOLTS, NUTS and DOG SPIKES.
5. COPPER TUBE PLATES (FLANGED).

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Pressed Steel Sleepers," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 4th June, 1926.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of Specification No. 1, of 10s. for each copy of Specifications Nos. 2 and 3, and of 5s. for each copy of Specifications Nos. 4 and 5.

Copies of drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1,
18th May, 1926. 2420

PUBLIC NOTICES

Epsom Urban District Council.

ELECTRICITY DEPARTMENT.

The Council are prepared to receive TENDERS for the following WORKS and PLANT :—

SECTION A.—Removal of Boilers and Setting Up as Fuel Tanks.
SECTION B.—Overhead Travelling Crane.
SECTION C.—Two 300 K.W. Diesel-driven Generators and Accessories.
SECTION D.—Oil Purifying Plant, &c.
SECTION E.—Cooling Tower.

Copies of the specification with forms of Tender can be inspected at the office of the undersigned and then obtained on payment of a fee of One Guinea for each copy, which amount will be refunded on receipt of a bona fide Tender.

Tenders, duly endorsed and addressed to the Clerk to the Council, 37, Church-street, Epsom, must be delivered to him not later than 7.00 p.m. on June 14th, 1926.

The Council do not bind themselves to accept the lowest or any Tender.

H. W. WATTS, M.I.E.E., M.I. Mech. E.,
Resident Electrical Engineer.
Electricity Works, Epsom,
May, 1926. 2388

Great Southern Railways Company.

CONTRACTS, 1926.

The Directors of the Great Southern Railways Company are prepared to receive TENDERS for the SUPPLY of the undermentioned STORES for twelve months, commencing 1st July, 1926.

	No. of Form.		No. of Form.
Asbestos Sheeting, &c.	40	Lead	161
Baskets	10	Leather and Leather Goods	12
Beaters and Picks, Cast Steel	135	Locks and Keys	19
Brake Sticks	141	Mantles for Gas, Upright	26c
Bolts, Nuts and Rivets	15	Mats, Fibre	10
Brooms and Brushes	13	Nails	31
Brass Fittings for Carriages	18	Oils, Gas and Paraffin	157
Do. for Water	26A	Oils, Mineral Lubricating and Cylinder	158
Do. for Gas	26B	Oil, Motion for Locomotives	159
Bricks, Fire, and Fire Clay	33	Oil for Carriage Axle-boxes	160
Buckets, &c., Glvd.	23	Packings	40
Cables, Electric	129	Paints, Mixed Ready for Use	142
Canvas and Sacks	6	Pins, Split, Steel Taper	144
Canvas for Wagon Tarpaulins	6A	Plates and Bars, Mild Steel	123
Castings, Mall. Iron	11	Purple Lake, Dry	2
Do., Steel	110	Rings and Washers, I.R., for Vacuum Brake	128
Cement, Portland	24	Ropes, Twine and Flax	4
Clothing, Oiled	9B	Soaps	3c
Corks	39	Soft Goods	7B
Cotters, Steel Split, Flat	138	Screws, &c.	14
Copper Plates for Locomotive Fireboxes	111	Sleeves, I.R., for Vac. Brake	128
Copper, Wire and Sheet	115	Springs, Volute	107
Diaphragms, I.R., for Vac. Brake	125	Saws	145
Drysalteries	3	Scythe Blades, Handles, &c.	21B
Felt, Roofing	8B	Signal Work Sundries	151c
Ferrules, Steel, for Loco. Boiler Tubes	134	Tin-plates	22
Flooring, Red and White	97A	Tiles, Ridge and Chimney Pots	32
Foundry Requisites	42	Tubes, Brass, Seamless	115
Glass, Sheet and Plate	27A	Tubes, Brass, for Loco. Boilers	114
Glass and China Sundries	27B	Tubes, Cold Drawn Weldless Steel, for Locomotive Boilers	153
Grates, Ranges, &c.	24	Tyres, Steel, for Carriages and Wagons	105
Hardware (Sundry)	17	Waste (Cotton)	5A
Hose Pipes, I.R., for Vac. Brake	127	Waterproof Clothing	9B
I.R. Goods	9A	Wire, Fence and Signal	30A
Implements, Sundry	21		
Iron Bar	151B		
Iron Castings (Signal Work)	132		
Ivory Drop Black in Turps	2		
Laces, Carriage	7A		

Forms of Tenders can be obtained on payment of 6d. each from the Stores Superintendent, General Stores Dept., G.S. Rlys., Inchicore, Dublin. Applications for forms by post must be accompanied by postal order. Stamps cannot be accepted. All enquiries for information should be directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Dept., Inchicore, on and after 14th instant, between the hours of 10 a.m. and 4 p.m. (except on Saturdays).

Tenders must be enclosed in the envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before 10 a.m. on Thursday, 3rd June, 1926.

The Directors will not consider any Tender unless it is furnished on the Company's form, and do not bind themselves to accept the lowest or any Tender.

The decision of the Directors will be communicated not later than Thursday, the 9th July, 1926, to those firms only whose Tenders are accepted.

By Order,
C. E. RILEY,
Secretary.
Kingsbridge Station, Dublin,
May, 1926. 2353

Great Southern Railways.

The Directors are prepared to receive TENDERS for the SUPPLY and DELIVERY of about 150 Tons of STEELWORK, consisting entirely of Pressed Steel Troughing for eighteen Small-span Bridges.

Drawings and specifications may be obtained from Mr. J. F. Sides, M. Inst. C.E., Chief Engineer, Broadstone Station, Dublin, on payment of £1 1s., which is not returnable.

The Directors do not bind themselves to accept the lowest or any Tender.

Tenders must be with the undersigned not later than 10 a.m. on Friday, 18th June, 1926.

C. E. RILEY, Secretary.
Kingsbridge Station, Dublin, May, 1926. 2377

Scarborough Corporation.

NEW IRTON WATER SCHEME.
CONTRACT NO. 6.
PIPE LAYING.

The Corporation invite TENDERS from experienced contractors for the LAYING of about 4 MILES of 15in. and 13in. CAST IRON PIPES and SPECIALS and SHORT LENGTHS of SMALLER PIPES, together with VALVES, HYDRANTS, METERS, &c. The pipes will be supplied by the Corporation.

The work will extend from the Irton Pumping Station of the Corporation to the New Service Reservoir at Spring Hill, Scarborough, Yorkshire.

Copies of the specification and form of Tender prepared by the Engineer, Dr. H. Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, may be obtained on application to the undersigned on or after Monday, the 3rd May. The application must be accompanied by the sum of £3, which will be refunded on return of the documents within seven days or after the receipt of a bona fide Tender and the documents required.

Tenders are to be sent in on the form supplied, and with the specification must be enclosed in a sealed cover endorsed "New Irton Water Scheme: Tender for Pipe Laying: Contract No. 6," and addressed to the undersigned, reaching him not later than 10 a.m. on Wednesday, May 26th, 1926.

Copies of the contract drawings may be inspected at the Town Hall on application to Mr. H. Richardson, Water Engineer, Water Department, Town Hall, Scarborough, and general information regarding the route of the pipe line from Mr. M. B. Mawson, Resident Engineer.

The Corporation do not bind themselves to accept the lowest or any Tender, and the acceptance of any Tender is subject to the sanction of the Ministry of Health to the loan for carrying out the scheme.

SYDNEY JONES,
Town Clerk.
Town Hall, Scarborough.
22nd April, 1926. 2278

PUBLIC NOTICES

Egyptian Government.

MINISTRY OF PUBLIC WORKS.
CONTRACT NO. 139.

TENDERS will be received by the Director-General, Main Drainage Department, 2 Sh. El Maleka Nazli, Cairo, Egypt, not later than Twelve Noon on the 1st of July, 1926, for :—

1. SUPPLYING, LAYING, JOINTING and TESTING approximately 7800 Metres Lineal of 40in. diameter CAST IRON PIPES (British Standard) and ACCESSORIES at and between the sites of the proposed new Sewage Pumping Station, Ameria, and the existing Sewage Pumping Station, Kafr el Gamous;

The SUPPLY and LAYING of approximately 4700 M.L. of 0.60 metre-gauge LIGHT RAILWAY and the CONSTRUCTION of a METALLED ROAD from Ein el Shams to Kafr el Gamous.

2. SUPPLYING, LAYING, JOINTING and TESTING approximately 1400 Metres Lineal of 36in. diameter of CAST IRON PIPES (British Standard) and ACCESSORIES at and between the site of the existing Sewage Pumping Station, Kafr el Gamous, and the proposed Emergency Storage Reservoir south of the old Suez Railway Embankment, and the SUPPLY and LAYING of a LIGHT RAILWAY, approximately 1300 M.L., 0.60 metre gauge.

3. SUPPLYING SPECIAL CASTINGS at Kafr el Gamous Sewage Pumping Station.

Tenderers shall have had previous experience in the supplying, laying, jointing, and testing of large cast iron pipe lines.

Two copies of specification, together with conditions, and one set of drawings will be supplied to tenderers against payment of £5 2s. 6d., which will not be returned. All persons desirous of obtaining these should apply to :—

The OFFICE of the DIRECTOR-GENERAL, Main Drainage Department,
2 Sh. El Maleka Nazli,
from 9 a.m. to 1 p.m.; or
The EGYPTIAN EMBASSY at London, or Paris, Rome, Washington, Brussels, Madrid or Berlin; or
The OFFICE of the CHIEF INSPECTING ENGINEER, 41, Tothill-street, Westminster, London, S.W. 1. 2426

Parish of St. Pancras.

GUARDIANS OF THE POOR.

The Guardians invite TENDERS for the SUPPLY of MATERIALS for HEATING WORKS, TWO WEIR FEED PUMPS, and a TANK with COIL to their Schools at Leavesden, near Watford, Herts. Copy of the specification can be obtained from my office as below.

Tenders should reach me in sealed envelopes, endorsed "Tender for Engineering Works," not later than 10 a.m. on Thursday, the 3rd June next.

B. CHAPMAN,
Clerk to the Guardians.
Guardians' Offices,
Town Hall,
Pancras-road, London, N.W. 1.
17th May, 1926. 2381

Napier Harbour Board (New Zealand).

RESIDENT ENGINEERSHIP.

APPLICATIONS are INVITED for the above POSITION.

Salary £1250 per annum.

Canvassing members of the Napier Harbour Board will disqualify applicants.

Applications to be addressed to the SECRETARY of the NAPIER HARBOUR BOARD and delivered at the Harbour Board Office, Napier, New Zealand, not later than Monday, October 11th, 1926.

A copy of the conditions can be obtained from the Board's London Agents, Messrs. W. and A. McArthur, Ltd., 18/19, Silk-street, Cripplegate, London, E.C. 2. 2415

Royal Sussex County Hospital, Brighton.

REQUIRED IMMEDIATELY, RESIDENT HOSPITAL ENGINEER, capable of taking responsible charge of and personally carrying out necessary repairs to all engineering equipment, including steam, water, gas, and electrical plant and services.

Candidates must have had experience of Hospital Work.

Applications with testimonials should be sent at once to the SECRETARY-SUPERINTENDENT, stating salary required, assuming house, fuel, and electric light are provided free by the Hospital. 2421

The Borough of Portsmouth

WATERWORKS COMPANY.
APPOINTMENT OF ASSISTANT ENGINEER TO THE COMPANY.

APPLICATIONS are INVITED for the APPOINTMENT, now vacant, of ASSISTANT ENGINEER to the Company. Candidates should be between 25 and 40 years of age and Corporate Members of the Institution of Civil Engineers would have preference.

Applications will be considered only from those who have had a full training (theoretical and practical) and a first-class experience in the design, construction, maintenance, and administration of waterworks. Knowledge of pumping machinery would also be advantageous. Commencing salary £500 per annum, rising by annual instalments of £33 to £650, less 5 per cent. obligatory contribution to the Company's Superannuation Fund.

The appointment is subject to the selected candidate satisfactorily passing an examination by the Company's Medical Officer, and may be determined after three months' notice on either side. Application should be made only on the forms which will be provided on request by the ENGINEER, Waterworks Offices, Commercial-road, Portsmouth, and must be delivered at that address as soon as possible, but not later than Friday, June 4th, 1926. 2275

The Commissioners for the Port of Calcutta

REQUIRE a MECHANICAL DRAUGHTSMAN for their Engineering Section. The salary offered is Rupees 600 per month, rising by Rupees 50 to Rupees 700. An unmarried man is wanted. Age not more than twenty-seven. Applicants must have served a full apprenticeship as mechanical engineer and have had good drawing-office experience. Must be good at calculations and estimating.

It will be necessary for the selected candidate to leave for India so as to arrive there about the middle of September.

Applications, with copies of references, must be sent to the undersigned not later than the 31st instant.

Mr. J. ANGUS, M. Inst. C.E.
10, Princes-street, Westminster, S.W. 1. 2385

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS UNLESS SPECIFICALLY REQUESTED.

ADVERTISER Wishes to THANK APPLICANTS to Box 1810 in issue dated 16/4/26 for Draughtsman, and to state that the VACANCY is now FILLED. P1803 A

CIVIL ENGINEER, Single, REQUIRED for Railway Surveys and Construction in Brazil. Two years' engagement, salary £480 per annum, free passages, quarters and outfit allowance. Experience Railway Surveys and Construction essential and knowledge of Portuguese or Spanish.—Box 39, c/o Judd's, 47, Gresham-street, E.C. 2. 2380 A

CIVIL ENGINEERING ASSISTANT REQUIRED Temporarily (probably two years) for a Water Company in Kent. One with some Ferro-concrete experience preferred.—Address, stating experience and salary required, 2330, The Engineer Office. 2330 A

For continuation of Small Advertisements see page 4.

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MOST MODERN "DISH-END" TYPE
WITH CORRUGATED SECTIONS.

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1	30ft. by 9ft. 3ins. by 200 lbs.	6464
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3	30ft. by 9ft. 3ins. by 120 lbs.	6465/6 and 6617
2	30ft. by 8ft. 6ins. by 160 lbs.	6467/8
2	30ft. by 8ft. 6ins. by 180 lbs.	6616/5
2	30ft. by 8ft. 3ins. by 140 lbs.	6212 and 6497
3	30ft. by 8ft. 3ins. by 120 lbs.	6469/71
2	30ft. by 8ft. 3ins. by 100 lbs.	6612/3
1	28ft. by 7ft. 6ins. by 160 lbs.	6614

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WHITE ANTIFRICTION METALS.

For Continuation of Small Advertisements,
See pages 4, 8, 130, 131, 134, 136.

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SITUATIONS OPEN (continued)

CONSULTING ENGINEER and MANUFACTURER has an OPENING in his London Office for a PREMIUM PUPIL. Must have a good general education, some knowledge of drawing an advantage. Would be given a thorough training with a view to a permanent post when proficient. Interview by appointment.—Address, 1986, The Engineer Office. 2019 A

ENGINEER.—REQUIRED AT ONCE by the Leamington Corporation, an ENGINEER to Take Charge at the Pump Room and Baths Establishment, of the whole of the Engineering Plant, Heating, Mechanical Filtration for Swimming Baths, &c. Must be capable of making all usual repairs. Wages £4 per week.—For form of application apply to Mr. J. J. KENNAN, Borough Engineer, Town Hall, Leamington Spa. 2363 A

ENGINEER (Under 41) WANTED for Central American Sugar Factory, speaking Spanish. Some experience in Factory Work, Electric Motors and Internal Combustion Engines. Salary £50 monthly, all found.—Box No. 334, Brown's Advertising Offices, 166, Buchanan-street, Glasgow. 2384 A

FACTORY SUPERINTENDENT REQUIRED by a Firm of Electrical Engineers, to Take Charge, under Works Manager, of the Switchboard Department employing about 1000 men. Must be energetic and have good organising abilities.—Address, giving full details of experience and qualifications, &c., 2233, The Engineer Office. 2233 A

LONDON REPRESENTATIVE REQUIRED by Midland Firm of Constructional Engineers; must have established connection amongst architects and engineers. Good salary and commission to capable man.—Address full particulars, 2335, The Engineer Office. 2335 A

MARINE ENGINEER ELECTRICIAN for India: Rupees 400 (equivalent to £30) per month; must hold 2nd engineer's ticket and must possess some testimonial as to skill as electrician. Fare out and home; 4 years' agreement with six months' notice either side.—Address, P1887, The Engineer Office. P1887 A

OIL ENGINE SALESMAN, Experienced, Capable of taking charge of the Oil Engine Department of a leading Firm of Manufacturers. Applicants should be of good address, have a good technical education and a knowledge of Oil Engines based on experience in the shops and outside; fully capable of preparing tenders and specifications for land and marine services, a connection with these services is essential. Those who cannot fulfil the above requirements need not apply. Applicants to give full particulars.—Address, 2393, The Engineer Office. 2393 A

THE MANAGING DIRECTORS of a Well-known Concern manufacturing important speciality and having over 1000 employees REQUIRE the ASSISTANCE of a thoroughly qualified ENGINEER on the sales side. A well-educated man of ability, with experience of Turbines and other Prime Movers, together with General Heavy Engineering Plant, essential. To a first-class man the position offers scope and liberal salary.—Address in confidence, stating age, salary, and qualifications, 2339, The Engineer Office. 2339 A

TANK ERECTOR WANTED; Must be Able to plan and carry out work economically. State previous experience. Salary commence £500 per annum.—Address, 2347, The Engineer Office. 2347 A

WANTED, a Thoroughly Capable SENIOR DRAUGHTSMAN, conversant with up-to-date practice in design of Air Compressors and qualified to supervise manufacture of same if required to do so.—Address, with full particulars of experience, 2418, The Engineer Office. 2418 A

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State age, experience, and salary required.
Address, 2360, The Engineer Office. 2360 A

WANTED for a Firm of Constructional Steel Engineers in Calcutta, a DRAUGHTSMAN, accustomed to Bridge Girders and Roof Work. Unmarried. Five years' agreement. Salary to commence at Rs. 500 per month, with annual increments.—Reply, with copy of testimonials, to Z. Y. 837, care Deacon's Advertising Offices, Finchurch-avenue, London, E.C. 2394 A

WANTED for a First-class Structural Works in Calcutta, a STEEL CONSTRUCTIONAL DESIGNER. Must also have had workshop experience. Unmarried. Commencing terms equivalent £650 a year. Five years' agreement.—Write, with copies of testimonials, to ALEX. LAWRIE and CO., Ltd., 14, St. Mary Axe, London, E.C. 3. 2395 A

WANTED, JUNIOR REFRIGERATION DRAUGHTSMAN.—State age, salary, and experience to PULSOMETER WORKS, Reading. 2410 A

CHIEF DRAUGHTSMAN REQUIRED IMMEDIATELY by old-established Firm of Machine Tool Makers.—Address, stating age, experience, qualifications, and salary expected, 2398, The Engineer Office. 2398 A

COMPETENT DRAUGHTSMAN REQUIRED by leading Manufacturers of Lifts. A quick worker able to prepare lay-outs for estimating purposes.—Address, stating experience, age, and wages desired, 2424, The Engineer Office. 2424 A

DRAUGHTSMAN CHECKER REQUIRED for Aircraft Work. Knowledge of Metal Construction desirable. State age, experience, and salary required.—Write, Box 264, T. B. Browne's Advertising Offices, 163, Queen Victoria-street, E.C. 4. 2400 A

DRAUGHTSMAN WANTED, Accustomed to Plant Lay-out, Foundry Plant, and Structural Work, and with good all-round mechanical knowledge.—Address, 2341, The Engineer Office. 2341 A

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REQUIRED for Important Argentine Railway, THREE competent MECHANICAL DRAUGHTSMEN; must have had practical experience of Railway Carriage and Wagon Work. Salary £450/500 p.a. on three years' contract; free passage provided. Age 25/30.—Write, giving full particulars education, training, experience, age, with copies (only) of testimonials, to Box L.B.A., c/o Davies and Co., 95, Bishopsgate, E.C. 2. 2382 A

SHIP DRAUGHTSMAN WANTED by Shipbuilders and Repairers in China. A senior or leading hand. Trained in a small shipyard with some experience in designing Light-draught Medium-sized Vessels. Aged 30 to 40. Salary £40 per month.—Address, fully detailing experience and technical training, 2396, The Engineer Office. 2396 A

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SITUATIONS OPEN (continued)

SEVERAL MECHANICAL and GENERAL ENGINEERING DRAUGHTSMEN REQUIRED in drawing-office of large Manufacturing Works. Men between 30 and 35 years of age, who have University Diploma or Engineering Degree and workshop and drawing-office experience preferred.
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SITUATIONS WANTED

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For continuation of Small Advertisements see page 8.

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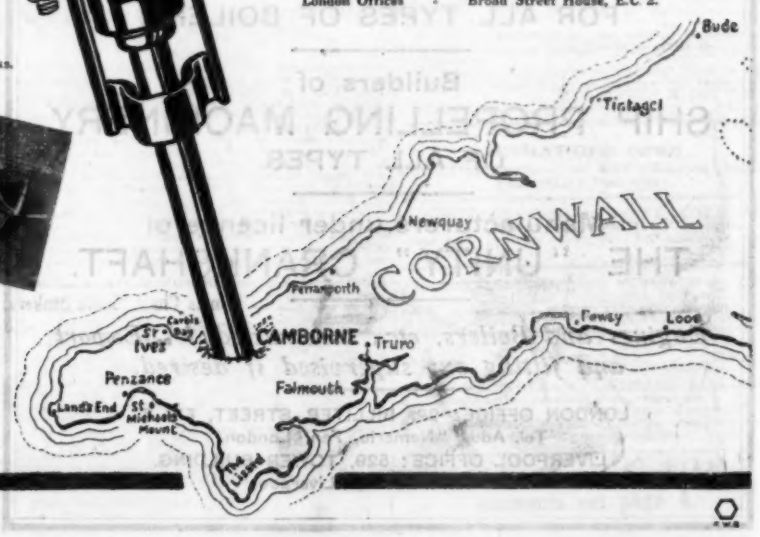

A Seven-Day Journal

The General Strike.

AT midnight, on May 3rd–4th, by order of the Trades Union Congress General Council, a general strike was declared in the principal industries of this country. A very complete response to the call to cease work was made by the members of the trades unions designated in the Council's order, and the morning of Tuesday, May 4th, witnessed the strike in full operation. The long-expected, long-threatened day had arrived, but never from the outset did the general public lose confidence as to what would be the outcome. How long the strike would last, what events would occur before it was ended, were freely debated, but at no time was any doubt felt that the Government would fail to surmount the peril in which the trades union leaders had placed the Constitution. Certain preliminary steps to meet the emergency had for some time previously been taken, and when the day arrived organisations were rapidly completed and arrangements for carrying on the country's essential services quickly extemporised. All over the country, voluntary workers offered their services in numbers more than sufficient to fill the vacant posts which the interests of the community demanded should not be left unoccupied. Fresh duties created by the emergency were eagerly sought. Many, cut off by the strike from following their usual avocations, were in a position to engage in whole-time voluntary work. Others, neither daunted nor fatigued by the additional burdens of their ordinary labour, came forward and rendered assistance in what should have been their well-earned leisure. Right from the start, it was evident to all not blinded by faction that the big majority of the population was solidly behind the Government in its resistance to the revolutionary and anti-social aspects of the general strike. From the start, too, it was clear that many trades unionists themselves did not believe in the wisdom of the step taken by their leaders, and that they did not intend to identify themselves with any rash actions designed to hamper the Government in its task of maintaining order and essential supplies. Not a few, too, stood by their employers or returned to work in defiance of their leaders' orders after a short absence from duty. With a strong well-led Government in power, a spirit of cheerful determination to surmount the crisis among the general public, and a lack of whole-hearted enthusiasm for the strike among the strikers themselves, only one end was possible. It came on Wednesday, May 12th, when at mid-day the Trades Union Council intimated an unconditional withdrawal of the general strike order.

The Origin of the Strike.

WHAT forces lay behind the action of the Trades Union Council in calling the general strike, what objects it was really intended to secure, are matters for the future historian to discover. We for the present can but record the ostensible facts. The action of the Trades Union Council had as its alleged object the rendering of assistance to the Miners' Federation of Great Britain in its struggle against a temporary reduction of wages and increase of hours. Since July, 1925, the coal mines of the country had been kept at work by means of a Government subsidy, which, all told, cost the nation some £20,000,000. By means of that subsidy, the coalowners were enabled to maintain the rates of pay fixed by the National Agreement of 1924. The period during which the Government consented to pay the subsidy expired on April 30th, 1926. The object of granting the subvention was to enable all concerned to be given time to examine the position, and, in particular, to afford a Royal Commission an opportunity of thoroughly investigating the present situation and future prospects of the coalmining industry. That Commission duly reported in an able and voluminous document, a summary of which can be found in our issue of March 19th, 1926. It is sufficient here to recall that the Commission recommended the reorganisation of the industry in considerable extent and detail, and that until that reorganisation bore fruit in the shape of renewed prosperity, the miners should consent to a readjustment of pay or hours. The Government and the owners expressed their willingness to accept the Commission's recommendations, but the miners' leaders took up an uncompromising stand against any reduction of wages or increase of hours. At the eleventh hour the owners offered the miners the wage rates in force in 1921, provided they would agree to return—for a period of three years only—to an eight-hour day. This offer was speedily rejected and a firmly expressed stand was maintained on the 1924 rates and a seven-hour day. With the approach of the end of the subsidy period, the owners issued the terms on which they were prepared to engage miners after April 30th, and on May 1st work at the mines ceased. Efforts continued to be made to keep the negotiations going. The Government even offered to secure the withdrawal of the notices and the continuation of the subsidy for a fortnight, if the miners' representatives would continue the discussions on the basis of the Coal Commission's report. This final offer was rejected, and the farther conduct of the dispute was handed over to the Trades Union General Council. That body immediately proceeded to level a virtual ultimatum at the Government. On Saturday, May 1st, it announced that unless a settlement of the miners' dispute were arrived at, a general strike in the vital services would be called for May 4th. The Council met the Government during the intervening days, but no agreement was reached, and the strike duly took place.

The Government's Case.

WHILE the Trades Union Council insisted that the action it had taken was not directed against the public, and that the strike had a purely industrial origin and object, the Government faced with the declaration took up the only possible attitude open to it, and declared that the Council had challenged the constitutional rights and freedom of the nation. It regarded the general strike in the serious aspect of an attempt to set up an alternative government, a point of view fully justified by the avowed intention of the Trades Union Council to usurp such governmental functions as the preservation of law and order and the distribution of foodstuffs and other necessaries. The Government, therefore, made it known in plain and strong words that it would not continue negotiations until it had acquired from the Council the unconditional withdrawal of the strike order.

The Unions Affected.

THE trades named in the Council's order to cease work were all those connected with transport, including railways, sea transport, docks, wharves, harbours, canals, road transport, railway and other repair work, and even ground services at aerodromes; the printing trades, including the newspaper press; the iron and steel, metal and heavy chemical trades, including engineering; building, with the exception of workers engaged on housing schemes and hospitals; electricity and gas supply, so far as they were concerned with the supply of power. Sanitary services were not to be interfered with, and the individual unions were charged to do all in their power to organise the distribution of milk and food to the whole of the population. The number of members of the unions supporting the policy of the Trades Union General Council was, it was stated, 3,653,527. Even though we multiply that number by five to allow for dependents and assume that all in the total arrived at were fully in agreement with the leaders' policy—and such we know was far from being true—we still find that the general strike represented the attempt of a minority of the population, some 38 per cent. in fact, to impose its will by force on the majority. Actually all the unions did not respond to the order, the most noteworthy example being provided by the Sailors' and Firemen's Union. That body obtained an important injunction in the Courts restraining certain of its branch officials from inducing its members to join the general strike, the judgment given reinforcing an earlier statement by Sir John Simon that the strikers had by failing to give due notice broken their contracts, and that the unions by calling upon them to cease work without full notice had committed an illegal act. It may here be recorded that the rules of the Trades Union Congress were altered at the Scarborough meeting last autumn for the purpose of giving the General Council power to call a general strike without reference to the members of the unions involved.

The Success of Volunteer Labour.

THE progress of invention would appear definitely to tend towards defeating attempts to hold a nation to ransom, such as we have just passed through. Twenty years ago with the motor vehicle in its infancy a general strike would in all probability have caused quick suffering and privation to most people in the land. As it was, the strike of May 4th–12th entailed no serious shortage of essential supplies anywhere, did not lead to anything but minor rises in the cost of food, and while it dislocated did not suppress the transport of passengers and mails. The motor vehicle saved the situation, and was perhaps the chief material means whereby the strike was rendered abortive. At the height of the crisis something like 2,000,000 gallons of petrol were, it is stated, being consumed in London each day. On the first day the cessation of traffic on the railways was all but complete, but by Wednesday, the 5th, volunteers were at their posts, and in a short time remarkably full emergency services were in operation on the principal lines. Here, again, the progress of invention told against the strikers, for on the electrified lines it was found possible quickly to recruit and train all the drivers required to operate the emergency services, and to provide a reserve for future expansion. Steam trains were run in considerable numbers, but, in general, drivers with previous locomotive experience had to be found for them. As an indication of the success with which the railways continued operations in spite of the defection of the large majority of their staffs, we may here set down the record of the Southern Railway. On the first day of the strike, Tuesday, May 4th, this company ran 134 passenger trains. On Saturday, May 15th, on which date the emergency services were still in operation and most of the work was still being carried on by volunteer labour, the company ran 1649 passenger trains. Altogether from midnight on May 3rd until the evening of May 15th the total number of passenger trains run on the Southern system amounted to 11,098, the number of goods trains to 504, and the number of train miles to 238,905. It may be added that on Monday, May 17th, the company resumed its full normal services. What was intended to be one of the strongest actions taken by the Trades Union Council, the attempted suppression of the dissemination of news, was at once and completely defeated by means of wireless broadcasting. During the strike five regular news bulletins were broadcast over the land and sea every day, with the result that the general population was actually more quickly informed of developments than it would have been had it had to rely on an uninterrupted newspaper service. In two other directions modern inventions helped to defeat the attempt to suppress the publication of information. The Stationery Office, taking over the establishment of the *Morning Post*, succeeded in producing within two days of the start of the strike a four-page paper, *The British Gazette*, and before the end came was printing and circulating over two million copies a day. The labour employed on the production of the paper was largely extemporised. To the technical success of the undertaking the linotype machine contributed very largely, for it is hardly conceivable that in the old days of hand setting the labour available would have given such a good account of itself. The aeroplane played another part in defeating the strike leaders' object, for certain London newspapers printed emergency editions in Paris and brought them over and distributed them by air. No member of the mechanical staff of Imperial Airways obeyed his union's order to cease work, and very few attached to other air transport companies responded. Some of the machines brought over as much as a ton of newspapers on each trip. From Lympne the distribution was conducted along the South Coast and as far north as Newcastle by means of de Havilland "Moth" light aeroplanes, each taking a load of 200 lb. of papers. Greatly increased passenger traffic was also experienced, the average number carried per day by Imperial Airways alone being about 160. It is gratifying to learn that throughout the period neither Imperial Airways nor the de Havilland Company had a single forced landing, and that every journey was completed according to schedule.

The Terms of Settlement.

ALTHOUGH the Trades Union Council called off the general strike unconditionally, the members of the individual unions were instructed to await the orders of their own executive councils before resuming work. Time had to be allowed for the unions and employers to negotiate the terms governing the restart of activity. For a short period many believed that the employers would in some cases seek to impose terms involving reduction of wages, increase of hours, or the abandonment by the workers of their unions. Following, however, a very strong lead given by Mr. Baldwin in the House of Commons, the settlements arrived at were all based on the continuation of the pre-strike rates of pay and hours. In one or two instances non-unionism or a break with the existing union was made a condition of re-engagement. In some cases certain minor customs or alleged rights that had filtered into trades union practices were removed. In general, however, an entire absence of harshness or any attempt to exploit the complete defeat of the general strike was manifested. The railways were among the first to reach agreement, and the terms arrived at may be taken as typical of those reached in other industries. Men, it was agreed, were to be taken back, in order of seniority, as soon as work could be found for them. The unions admitted that they had acted wrongfully in calling the strike and that the companies by reinstating the men did not surrender their legal rights to claim damages from the strikers. It was agreed that the unions would not again instruct their members to strike without previous negotiations, would not give support of any kind to any of their members taking unauthorised action, and would not encourage supervisory workers to take part in any strike. The companies reserved the right to remove certain persons to other positions as a result of the strike. The settlement was not to extend to anyone who had been guilty of violence or intimidation. This settlement on the railways provided an example to other industries, and by Monday, May 17th, general agreement had been reached in all the chief trades.

The Coal Dispute.

ONLY the original coal dispute remained outstanding. While the miners continue idle the failure of the general strike to advance their cause in any respect whatever has undoubtedly induced in some of their leaders a less uncompromising attitude than they displayed beforehand. True to his promise, Mr. Baldwin immediately after the general strike order had been withdrawn set about reopening negotiations with the mineowners' and miners' representatives. A new scheme of settlement was advanced by the Government based on the recommendations of the Royal Commission and involving further State assistance to the extent of £3,000,000.

Electric Train Testing on the Metropolitan Railway.

By GEORGE HALLY, C.M.E., Metropolitan Railway.

No. I.

Description of the Line.

Sixty-three years ago the first underground railway—the Metropolitan—was opened to the public. It was a modest undertaking, 3¾ miles in length, constructed to serve as a communicating link between the City of London and the west-end residential districts. With the growth of the Metropolis, the line gradually extended, until to-day its trains operate on a single-track mileage of 187 miles, to a distance of over 50 miles from the head station in London—Baker-street. From the mileage point of view, it cannot compare with the four trunk lines of Great Britain, but as a transport enterprise it occupies an important position. In 1863 it carried 9,455,175 passengers; in 1924, 153,304,309.

To-day the railway is principally engaged in bringing the London man of business to the capital in the morning, in carrying him upon his lawful occasions throughout the day, and in restoring him to his country home at night. The main line passes through some of the loveliest of England's scenery, now known as "Metroland" from its association with the railway. The development of this large district is fostered by the energetic management of several land companies conducted as subsidiaries to the railway company, but under practically the same direction. The clearing of the land, the making of the roads, the designing, building and financing of the houses and estates, all are undertaken by the railway's vigorous progeny. The parent provides a frequent, fast and comfortable service to the business and shopping centres of London, commencing at 5.15 in the morning and continuing with monotonous regularity until the small hours of the next day.

It will be noticed on the map—Fig. 1—that the main line runs towards London in a south-easterly direction to Baker-street Station—the headquarters of the company and one of the great nerve centres of London's traffic. From this point the line goes east on the Inner Circle towards the City and also turns in a westerly direction towards South Kensington, Hammersmith and the Great Western main line, thus providing with its various feeders a convenient and busy means of transportation from the City to the east, south, west and north-west of London.

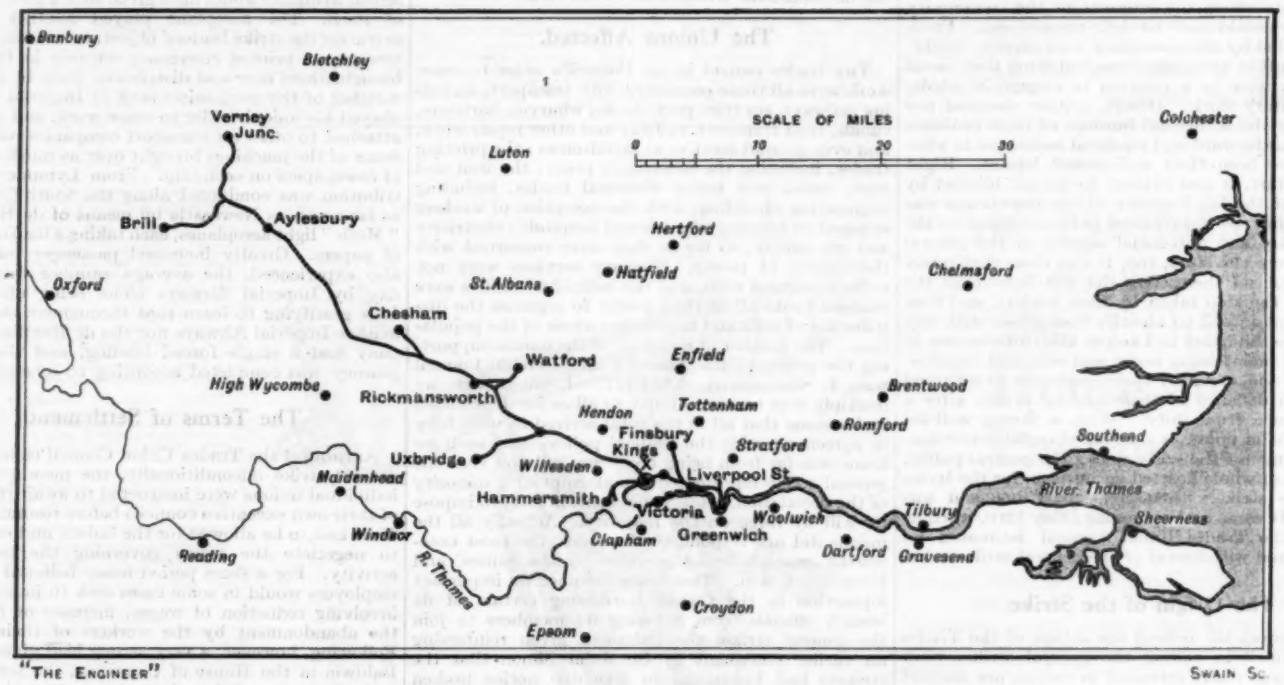

FIG. 1—MAP OF THE METROPOLITAN RAILWAY AND SURROUNDING DISTRICTS

Electrification.

At first the whole of the line was operated by steam locomotives, but in 1902 electrification was taken in hand, and to-day there are 129 miles of electrified single track, which include all parts of the London system and the main line as far out as Rickmansworth, north of which traction is provided by steam locomotives. The fourth-rail system is used, direct current at 600 volts being supplied from the company's power station at Neasden, which is equipped with a plant having a total capacity of 42,000 kilowatts, using water-tube boilers fired with coal. High-tension current at 11,000 volts is distributed to thirteen sub-stations, and there stepped down through static-transformers and rotary converters to supply the track.

The conductor rails are of Vignoles section, weighing 120 lb. to the yard, bonded with copper bonds and carried on vitreous porcelain insulators laid on the sleepers. The negative rail lies between the running rails, which are of standard section, 95 lb. to the yard, and the positive rail lies close to the outer running rail, protected, where necessary, by a stout wooden guard. The gauge of the running rails is the British standard of 4ft. 8½in.

Signalling throughout the electrified portion of the line is automatic, using current supplied from the sub-stations. The semaphores assume the upper position when clear, and fall to a horizontal position when at danger. The latest extensions are equipped with three-aspect light signals.

Traffic Density.

The maximum traffic density on the Metropolitan line naturally occurs in the morning and evening. Between eight and ten in the morning of any week-day 168 trains arrive at the six platforms in Baker-street Station; some terminate there, others pass on to the Circle stations. During the busy times of the day forty trains call at Euston-square Station on the Inner Circle each hour, some coming from the main line, others from Hammersmith or the Great Western Railway—all proceeding towards Liverpool-street or New Cross. Intermingling with these run the Inner Circle trains connecting the City with the west of London and the main line termini—a continuous stream completing the round trip of 13 miles, with its twenty-seven stations, in 48 minutes, and running for twenty hours a day.

Rolling Stock.

On account of the diversity of the railway's operations, there is a multiplicity of stock as follows:—

33 motor cars, each fitted with four 200 horse-power Westinghouse motors.
60 motor cars, each fitted with four 150 horse-power Westinghouse motors.
28 motor cars, each fitted with four 200 horse-power B.T.H. motors.
47 motor cars, each fitted with four 150 horse-power B.T.H. motors.
32 motor cars, each fitted with two 125 horse-power B.T.H. motors.
88 first-class trailer cars.
50 composite-class trailer cars.
187 third-class trailer cars.
21 electric locomotives, each fitted with four 300 horse-power motors.
38 steam locomotives.
46 first-class compartment stock coaches.
7 composite-class compartment stock coaches.
101 third-class compartment stock coaches.

The electric trains are made up of six or seven vehicles, all motor cars being arranged for multiple-unit operation. During the slack times of the day the trains are divided and run as three or four-car units, re-forming again when the evening rush commences. The cars equipped with Westinghouse motors are fitted with electro-pneumatic control gear, but all others have the all-electric type. The whole of the electric car stock is fitted with Westinghouse brakes, central buffing gear and automatic couplers.

The compartment stock is used for main line trains, and is hauled by electric locomotives as far as Rickmansworth, whence steam locomotives complete the journey to Aylesbury or Verney Junction. The electric locomotives are fitted with Westinghouse and vacuum brakes, so that either compartment stock or car stock may be handled, as desired. Side buffers and automatic couplers are fitted, and in general dimensions the locomotives follow the lines of their steam prototypes.

In all cases current is picked up from the rails by means of collector shoes, each one weighing 12 lb., and not only are shoes fitted to the motor cars, but also to a certain number of trailer cars, so that when one part of the train is standing on a gap in the conductor rails, current can still be picked up by the remaining shoes and passed through the train-line power cables to the motor car.

The mechanical engineering department is responsible for all matters relating to the design, construction, repair and maintenance of the rolling stock and locomotives. The main repair works are situated at Neasden with several subsidiary depôts in other places, the total staff numbering 711.

Reasons for Tests.

In order to provide data for technical and accounting purposes, it is necessary from time to time to ascertain the amount of current being used by the different types of rolling stock. This can be obtained only by carrying out a prolonged series of tests upon trains working under service conditions and operating on different parts of the system. When the first trip was in contemplation there appeared to be no difficulty in collecting any desired data, but closer acquaintance revealed many obstacles, and no little time and thought had to be expended before a satisfactory solution was reached.

A special testing car could not be attached to any of the trains, as already they were the full length of the platforms, and, moreover, the results would be affected by the load imposed on the motors through having an extra vehicle to haul. Nor would a special train have given suitable records even if the traffic density had permitted its inclusion. It was impossible to utilise the luggage compartments, as not only were they too small, but unlighted and ill-ventilated. Recourse had, therefore, to be made to the passenger space, and arrangements had to be such that all the equipment could be placed aboard with the minimum amount of alteration to the cars and inconvenience to the passengers. Further, the whole of the gear had to be readily portable so that the testing of any train or car could be undertaken at short notice.

As the tests were to continue without any pause from 8 a.m. to 12 midnight, it was realised that the staff would require to work in two shifts in order to provide intervals for meals and rest, whilst it was necessary to consider especially the comfort of the observers on account of the physical strain to which they were subjected. Above all, it was essential that the records should be as complete and accurate as circumstances permitted, for not only would the designs of new rolling stock depend largely upon the figures obtained, but they would be used by the accountant in making up his charges to other companies the rolling stock of which operates on the Metropolitan system.

Instruments.

It was decided that all necessary information could be obtained by the use of the following instruments:—

One recording voltmeter.
One recording ammeter.
One speed recorder.
One brake application recorder.
One stop and start recorder.
One direct reading voltmeter.
One direct reading ammeter.
Three direct reading watt-hour meters.
Stop watches, &c.

The potentialities of all instruments on the market

were carefully investigated and eventually a "traction recorder" combining in one instrument the first five items on the above list and made by Messrs. Evershed and Vignoles, Acton-lane Works, Chiswick, London, England, was put under test in service conditions. The experience gained thereby pointed to the desirability of several alterations of a minor character, and it may be of interest to record them.

As the terminal stops are often less than three minutes it was essential that the record be continuous, and as a day's testing required 240ft. of chart, arrangements had to be made for permitting the new chart to be joined to the old one without stopping the instrument. It was found that the clearances between two of the pens had to be increased, for when the train lurched heavily there was a danger of the pens fouling each other. Flat plates had to be placed below the charts so as to facilitate writing upon them. Additional protection was afforded to the current-carrying parts of the instrument to eliminate the danger of shock to the operator. Lastly, the clock regulator was encased and sealed, as on the first occasion it was noticed to have been accidentally altered during the test, so that the speed of the charts was greater at the end of the day than at the beginning.

These few alterations were carried out, and when the first official trial was run the instrument proved of the traffic. It has been found on test that this record when measured with a scale agrees with the stop watch times to within half second.

The third pen records the amount of current used by two motors. The shunt is placed in the main power positive cable running from the switchboard to the motors, the range of the chart being from 0 to 1500 ampères.

The fourth pen records the brake applications and in construction is similar to the stop and start recorder, but in this case the magnet coil operating the pen spindle is energised by means of a switch controlled by a piston in direct communication with the Westinghouse brake cylinder. This mechanism is set to work with an air pressure of 5 lb.

The fifth pen records the speed of the train and is actuated by means of an Evershed electrical speed transmitter, mounted on the leading bogie of the trailer car adjacent to the motor car being tested. The belt drive for the transmitter comes from a pulley mounted on one of the axles. This arrangement is necessary through the impossibility of fitting a pulley on the axles of the motor cars, as they are totally enclosed by the castings of the motor yokes. The truck upon which this driving gear is mounted is interchangeable with all others on the railway system, so that speed trials of any steam or electric train can be carried out by placing this particular truck under any vehicle in the train and mounting the recording instrument in a convenient position either in the car or in one of the compartments. In order to make provision for varying wheel diameters on the trailer car a wheel corrector is introduced in the main leads from the transmitter to the recorder and is adjustable for wheels between the diameters of 35in. to 42in. This wheel corrector is calibrated before the commencement of each trial.

Charts.

It will be noted that two charts are used for taking the records, the reason for this being that if the five pens were operating upon one strip of paper it would be of excessive width, 11in. overall, and awkward to handle. Also, the instrument is occasionally used for testing the speed of steam trains, in which case only one of the charts is required. Again, occasions arise when the voltage on the track has to be recorded, and the instrument is then used with the left-hand chart only. When both charts are used, however, it is necessary to have some means of synchronising them after they have been removed from the instrument, and for this purpose a rubber stamp is used to mark simultaneously a straight line on the inner edges of each strip, whilst the charts are passing through the instrument.

Electrical Movements.

The voltmeter, ammeters and speed recorder are all of the moving coil type and constructed to provide a high degree of accuracy. The jewels upon which the pivots are mounted are spring borne, so that if any end thrust be placed on the spindle the compression of the spring relieves the point of movement from injury and so preserves the fine point of the pivot. Oil dashpots of a special shape to prevent the escape of oil are fitted, and by varying the viscosity of the oil contained therein the effects of excessive oscillations of the train may be partially or wholly damped out. The pens for the voltmeter, ammeter and speed recorder are of the syphon type, taking their ink from two troughs, and passing it through an orifice ·002in. in diameter. The troughs are readily removable and it has been found that the pens give a satisfactory and clearly defined line of unvarying thickness for twenty hours on end. The pens for the stop and start recorder and brake applications are filled by hand, as occasion demands, usually once in three hours.

Chart Driving Gear.

The chart driving mechanism is operated by a clockwork motor, the winding handle of which will be seen on the right-hand side of the instrument in Fig. 2. A solid shaft runs through the two driving drums, so that the charts are kept in absolute synchronism. The taking-off spools are driven from the main shaft by means of a spring belt, the spools themselves being held on end bearings with spring clips. They are fitted with removable ends, so that the finished chart may be quickly removed. The speed of the charts may be altered as desired from 1in. to 6in. per minute by changing the ratio of the driving gears shown on the right-hand side of the instrument in Fig. 2, but it has been found from experience that a speed of 3in. per minute is the most satisfactory one for Metropolitan Railway conditions, where the time which elapses between stops is in many cases less than two minutes. Extreme accuracy is obtained from the fast-moving chart, and yet with the longest run the overall length is not excessive.

The arrangements for feeding in the chart paper are of interest. Fig. 3 shows the unused charts mounted on their spools at the back of the instrument. In this position they can be dropped into place without any fear of disturbing the recording pens. The paper passes through a slot in the wooden back of the case straight in below the pens, and thence to the taking-off spools. The charts are perforated on both edges, the holes engaging with pins mounted upon the driving drum. Knife-edge guides are placed close to the drums to keep the charts in contact with the brass tables underneath them, so that a smooth, flat and regular surface is provided for the pens to travel upon. The ends of the spools are slotted, so that the amount of paper still unused may be ascertained at a glance. When the observer notices that the unused charts are approaching their ends, the spools are removed, the rolls are unwound and the paper is

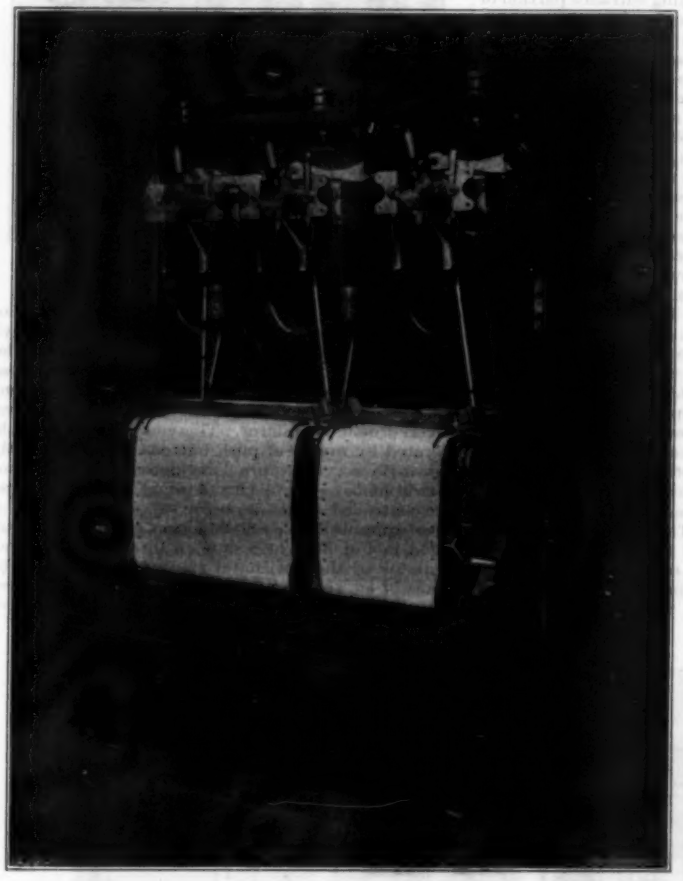

FIG. 2—MURDAY TYPE TRACTION RECORDER WITH COVER REMOVED

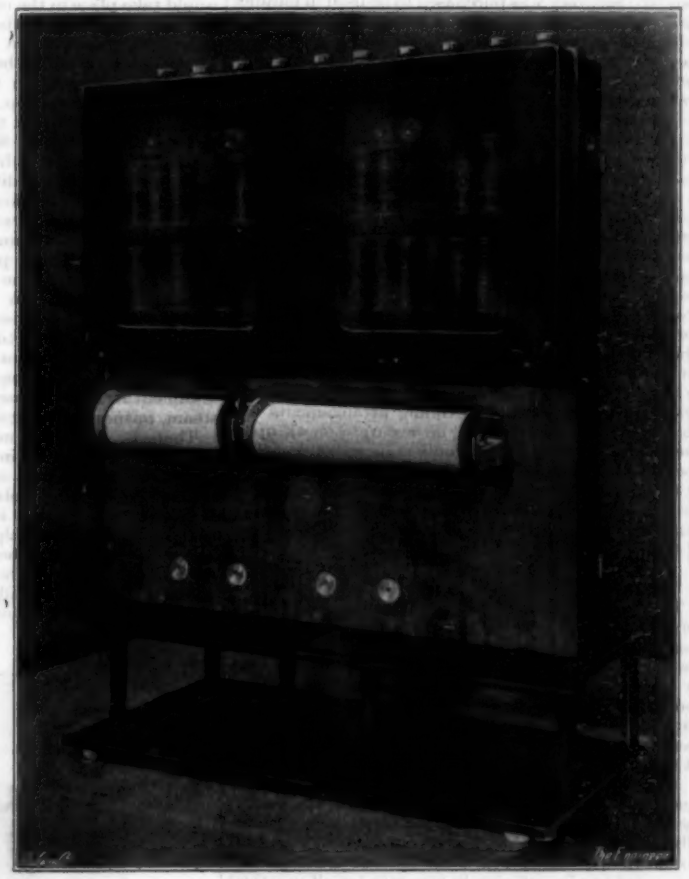

FIG. 3—REAR OF MURDAY TYPE TRACTION RECORDER SHOWING UNUSED CHARTS

to be accurate and convenient in all respects, eminently suitable for the purposes for which it was designed.

Traction Recorder.

Fig. 2 shows the traction recorder with its outside wooden cover removed and the insulating cover over the moving parts of the instrument taken away so as to expose the interior. The instrument is of the Murday type, wherein the pens describe straight lines upon a continuous chart. It will be noted that there are five pens writing upon two charts and, reading from left to right, they give the following records :—

1. Volts.
2. Station stops.
3. Ampères.
4. Brake applications.
5. Speed.

The first pen records the voltage on the track, the leads for this instrument being taken from the switchboard terminals of the main power cables coming up from the collector shoes, the range of the chart being from 400 to 700 volts.

The second pen records the times spent in running and at the stations. The magnet coil operating the pen spindle is energised by means of a 5-ampère switch, opened and closed by an observer wholly engaged upon this duty. A particular importance attaches to this record, as it is essential with dense traffic working that the time spent at the stations be reduced as far as possible, and although the speed curve gives some general information on the subject, it is not sufficiently accurate for the close regulation

passed below the instrument case through to the table in front, where the end of a new chart is gummed on, exact registration being afforded by mounting the ends of the charts on a metal fixture provided with suitable studs engaging in the holes on the charts. As soon as this operation is completed, the new rolls of chart paper are placed on the spools, which, in turn, are replaced on their clips at the back of the instrument and another 65ft. of paper are available for a further run of five hours. It will be noted that throughout this chart-changing process the instrument is neither stopped nor interfered with in any way, and it is therefore possible to ensure that a complete record of each and every run is obtained on one strip of paper.

It was found during the preliminary tests that the charts had a habit of finishing during some run of particular importance, and the instrument had to be stopped in order to get new chart paper in place. The record was thus incomplete, even although the complete changing occupied less than two minutes. However, with the arrangements already described the chart can be made perfectly continuous and of any length whatsoever.

Direct Reading Instruments.

In order that there should be no doubt of the accuracy of the results obtained from the recording instruments, a direct-reading ampère meter of sub-standard accuracy was purchased to be used in parallel with the recording ammeter. Two direct-reading voltmeters were also obtained so as to provide a specially accurate check upon the recording voltmeter. It might here be mentioned that after the first preliminary run with the recording instrument, the voltage drop in several sections of the line was found to be so great that doubts were cast upon the accuracy of the instrument, and it was deemed essential to have these direct-reading instruments to act as a check upon the recorder. The latter instrument was found to be accurate within 1 per cent. at all times. The start and stop indicator is checked by means of a series of stop watches, two of which are started when the train commences its journey and stopped when it reaches the terminal station, thus providing the overall time of the trip. Two watches are used to check the running times, being started when the train leaves a station and stopped when it arrives at the next one. Two other watches are used to time the duration of the stops in the stations. It will thus be seen that the timing arrangements are quite complete, and provide an accurate check upon the operation of the start and stop recorder. The speed recorder is checked by integrating the charts at the conclusion of the trip. As the exact distances between the stations are known and the running times are obtained from the stop watches, the accuracy of the speed charts can be readily determined.

Current Consumption.

The most important data, however, are those referring to the current consumption, and in order that the results may be sufficiently accurate, three watt-hour meters are installed in series and are read by two independent observers. At the expiration of the trials a selected number of the voltage charts and ampérage charts are carefully integrated and the results obtained therefrom compared with the readings of the watt-hour meters.

It will thus be observed that every care is taken to ensure the errors either of the observers or the instruments are reduced to minima, the results being generally accurate to within 1 per cent. Considering all circumstances under which the records are obtained, this is held to be sufficiently accurate for all practical purposes.

Proposed Method for the Automatic Superheating of Steam.

It would appear at first sight as an impossible thing that steam could be raised in temperature except either by the application of heat at some temperature higher still, or by the use of some mechanical agency such as a compressor. That steam may be superheated to a certain extent by throttling is, of course, well known; but that is another matter. After being throttled, steam is in a superheated condition not because its temperature has been raised, but because the saturation temperature corresponding to its new and lower pressure is less.. Its actual temperature is indeed somewhat less than before throttling, owing to the "Joule-Thomson effect." To get a final temperature higher than the initial temperature without the use of external heat would clearly be possible by using a part of the steam to drive a compressor which would compress the remainder of the steam and thus raise its temperature. Such an arrangement would be automatic in the sense that it would operate without any supply of heat or power from outside, but there is no point of view from which it would appear very attractive. The necessity of having an engine and compressor, even without considering the unavoidable losses to which they would give rise, would be sufficient to condemn the scheme from any practical standpoint. It has, however, been suggested, originally, we believe, by Professor Watkinson and more recently by Mr. R. H. Parsons, that there is, at least theoretically, a way by which steam may be automatically raised in temperature without the use of any running machinery whatever. The principle is the reverse of that employed in an ordinary refrigerating cycle. In the latter the working fluid is temporarily heated by compression. Heat can be abstracted from it when in this condition, so that when restored to its original pressure it is cooler than before.

The converse of this process as applied to the heating of steam would be temporarily and artificially to cool the steam by expansion in order that heat might be able to flow into it. The acquisition of this heat would result in a higher temperature when the original conditions of pressure were restored. Since, by hypothesis, the steam is below its original temperature at the time of receiving heat, it could obviously absorb its additional heat from some of the original unexpanded steam. Thus, at the expense of some of the original steam, we could deliver the remainder at a higher temperature, and the process would go on automatically. It could, moreoever, be repeated a number of times, raising that part of the steam which was not used up in the process to a temperature far greater than that which any of the steam originally possessed.

To carry the idea into effect, steam might be caused to flow, under a very slight difference of pressure, through a tube of Venturi form. Adiabatic expansion would take place in the converging entrance portion of the tube, resulting in the steam having a lower pressure and temperature when passing the throat. The pressure drop at the throat has, of course, been taken advantage of in the design of steam meters. The temperature drop, however, should make it possible to impart heat to the steam at that point by jacketing the throat with steam of the original temperature. In the diverging part of the Venturi tube, under ideal conditions, adiabatic compression would take place, the kinetic energy produced during the previous adiabatic expansion effecting an adiabatic compression of the steam and so restoring its pressure. If it should be found practicable to raise the temperature of steam in the way suggested, the idea may find useful application in connection with the reheating of steam between the high and low-pressure cylinders of a steam turbine. There would be no need to return the steam to the re-superheaters in the boiler-room, as the required temperature could be obtained at the turbine itself, a certain amount of steam, naturally, being used up in the process.

There is, of course, no theoretical thermodynamic gain by heating steam in the way proposed. One can always be certain that any action which takes place by itself in Nature involves a loss of available energy. Heat will not up-grade itself on the whole, any more than water will run uphill. The fall of some of the water, however, may be used to pump the rest to a higher level, although the final result is inevitably that there is less energy available for work than there was before. It may be, however, that 1 lb. of water at the height of 100ft. is more to be desired than 2 lb. of water at a height of, say, 60ft., and under such circumstances the loss of available energy is justified. If one is content to exchange a quantity of steam at a low temperature for a less quantity at a high temperature, and to ignore the increase in entropy which the conversion involves, then a self-heating process may have its advantages. Whether it is possible in practice to get any considerable amount of heat into steam during the brief period of passage through the throat of a Venturi tube is a matter for experiment. The velocity of the steam will be of the order of 1500ft. per second, so that the time is short for heating, with any reasonable length of throat. By proportioning the tube with a very small hydraulic mean depth circumstances would be more favourable to heat transmission, but, on the other hand, frictional losses would be increased and the efficiency of the tube as a whole would probably be greatly decreased. To carry out the principle of self-heating of steam in actual practice might therefore be difficult, but the idea is certainly an interesting one.

Alternating-current Pressure Regulators.

No. IV.*

We believe that induction regulators were first manufactured by the Brown Boveri organisation, the address of which in this country is British Brown Boveri, Ltd., Trafalgar House, Waterloo-place, S.W. 1.

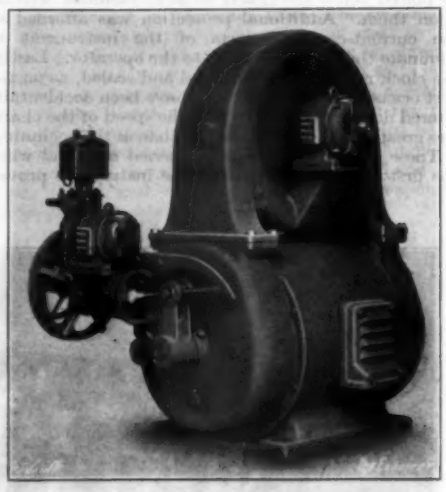

FIG. 35—SLOW-MOTION INDUCTION REGULATOR

One of this company's regulators has been in operation on the Newcastle Electric Supply Company's system for over twenty-five years. It is controlled on the original Thury system, which has now long been superseded by a new and more rapid system, that involves the use of the well-known Brown-Boveri pressure regulators; slow-motion electric motor controlled and rapid motion oil pressure controlled regulators being supplied.

An example of the slow-motion regulator is illustrated in Fig. 35, which shows a three-phase 50-cycle regulator of the horizontal shaft pattern cooled by means of an air blast provided by the fan to be seen on top of the regulator, and operated by an electric motor shown on the left of the illustration. The regulator is designed for an incoming pressure of 4700–5300 volts and an outgoing pressure of 4520–5400 volts, the power passing through the regulator being 625 kilovolt-ampères at 5400 volts on the regulated side, and the actual power of the regulator itself is 90 kilovolt-ampères. An illustration of the rapid-motion control gear is shown in Fig. 36, and the corresponding regulators, which are coupled to the vertical shafts in Fig. 36, are shown in Fig. 37. These are vertical-shaft, oil-immersed, natural-cooled regulators, designed for three-phase, 50-cycle alternating current, and for an incoming pressure of 5400–6600 volts and an outgoing pressure of 6000 volts. The power passing through each regulator is 270 kilovolt-ampères at 6000 volts on the regulated side

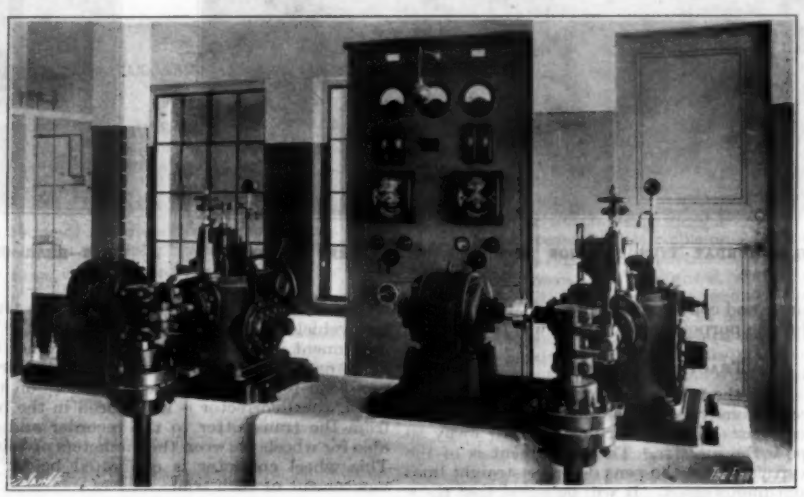

FIG. 36—RAPID-MOTION GEAR FOR INDUCTION REGULATORS—BROWN, BOVERI

* No. III. appeared April 30th.

and the actual power of each regulator is 30 kilovolt-ampères.

The speed at which the two types of control gear operate varies to some small extent according to the size of the induction regulator. On an average the motor control gear takes about thirty seconds to move the rotor of the induction regulator from the extreme position of minimum boost to the extreme positive boost position, whereas the oil pressure control gear moves the rotor to the same extent in from 2 to 5 seconds. The first system of control is suit-

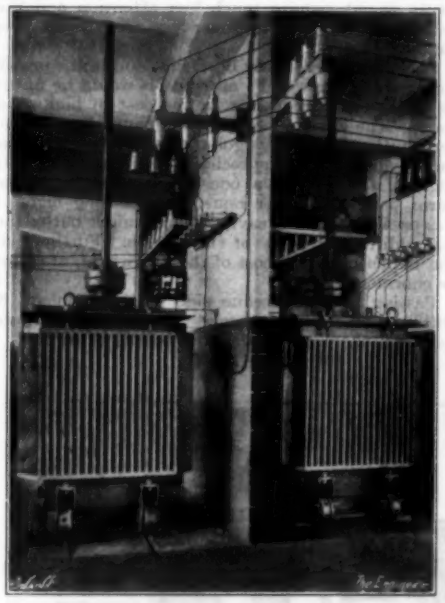

FIG. 37—OIL-IMMERSED INDUCTION REGULATORS

able for all classes of service which do not involve widely fluctuating loads, as on ordinary lighting and power systems; but when the fluctuations are very large and rapid, the oil control system is recommended. For highly fluctuating traction loads, for instance, the slow motion gear would scarcely be suitable.

A diagram of connections for a motor-controlled automatic pressure regulator, as supplied by British Brown Boveri, Ltd., is shown in Fig. 38, where I. is the automatic pressure regulator, II. the pressure transformer supplying this regulator, III. the regulator's current transformer, IV. a rotary electromagnet which controls the change-over switch V., and VI. the motor which operates the induction regulator VII. A resistance is shown at VIII. in circuit with the rotary electromagnet IV. to limit the current taken by that magnet. IX. is a limit switch which cuts off the power when the induction regulator has completed its travel, and X. the brake-lifting magnet, which removes the brake when the driving motor VI. is energised by the reversing switch V. The rotor of the induction regulator is, of course, turned by means of the motor VI., which drives through reduction gearing and a link. The motor is under the control of the rotary electromagnet IV., which operates the reversing switch V.; whilst the rotary electromagnet is under the control of the pressure regulator. The field of the rotary magnet is permanently energised by a small current of constant value, and as long as the sectors of the pressure regulator are in the mid position on the contacts of the regulating resistances, the rotary magnet remains at rest, but any alteration in the feeder pressure causes the contact sectors to roll in one or the other direction and to produce a difference of potential and current in the armature of the magnet, with the result that the rotor will be turned in a suitable direction. In

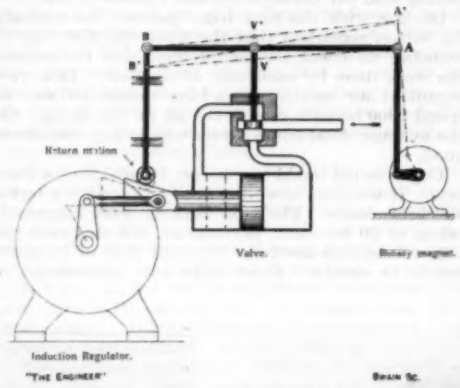

FIG. 39—OIL PRESSURE RELAY

the diagram, Fig. 38, the pressure regulator is represented purely diagrammatically, with one moving sector, whereas in practice two sectors are employed. The essential features of the scheme, however, are that the rotary magnet IV., which is under the control of the pressure regulator I., closes the reversing switch V. in one or the other direction, according to whether the line pressure is low or high, and the operating motor VI. drives the rotor of the induction regulator and causes the pressure to be raised or lowered according to circumstances.

In order to bring back the moving system of the automatic regulator quickly into its mid position after it has operated, an electrical return device is employed. It consists of two resistances with movable contacts, to be seen below the main contacts of the reversing switch V. Assuming that the line pressure regulation is in progress in the manner described, the movement of the rotary magnet will cause one of the resistances to be put into series with the regulator coil, so as to raise the equilibrium pressure by about ½ volt, the object being to bring the moving system of the regulator back to its mid-position before the regulation of the line pressure has been completed, because, on account of its slight inertia, some little time will elapse before the entire regulating mechanism comes to rest.

As soon as the regulator takes up its mid position the rotary magnet also returns to its mid position and disconnects the motor from the line, whilst at the same time the motor brake is applied and the return resistance is again short-circuited, thus restoring the equilibrium pressure of the regulator to its normal value. If the regulated pressure begins to decrease on account of an increase in load the regulating process will be repeated, but in the opposite sense, and the reversing switch will interchange the phases of the driving motor which cause the rotor of the induction motor to turn in the opposite direction, thus decreasing the feeder pressure. In this case resistance is introduced into the regulator circuit so as to reduce the equilibrium pressure of the regulator by about half a volt. The moving system of the pressure regulator will then return to its mid position, but the rotary magnet will complete the regulation. If it is desired to compensate pressure drop in feeders the pressure regulator must be compensated in the ordinary way by means of an adjustable shunt. In the event of the induction regulator reaching either of its end positions the corresponding limit switch opens and prevents further rotation, but the motor is able to run in the opposite direction as soon as any alteration in pressure takes place in the opposite sense. As previously stated, when very rapid pressure drop is required, the automatic gear just described is unsuitable, and the more rapid apparatus shown in Fig. 36 is then utilised. It consists of an oil pressure relay which is under the control of a voltage regulator, as shown in the diagram Fig. 39. The rotor of the induction regulator is operated by the piston of the oil relay, the oil pressure for actuating this relay being supplied by a pump. In principle the control gear for the relay is very similar to that used in conjunction with water turbines, except that in place of the centrifugal governor a rotary electro-magnet is used, and this magnet is influenced by the pressure regulator. Referring to Fig. 39, the valve rod V has a normal position of equilibrium, and if the rotary electro-magnet turns, however slightly, the control lever A B will be moved momentarily about the point B and the valve rod will be brought to the position V^1.

FIG. 40—HAND-OPERATED INDUCTION REGULATOR

Oil under pressure is admitted to one side of the piston of the oil relay, with the result that the rotor of the induction regulator is caused to turn. In order to avoid over-regulation a mechanical return motion is provided as shown. As soon as the movement of the valve occurs the free end B of the lever is brought into the position B^1, and the valve will consequently be brought into its original position V. The control lever will now have taken up a new position of equilibrium $A^1 B^1$, which corresponds to the altered conditions of the pressure, the induction regulator having in the meantime been displaced through a certain angle. If it is required to regulate in the opposite sense the control lever will take up the position B^1 A and will immediately afterwards be returned to its starting position A B by means of the return motion. Besides the gear shown, the automatic regulator itself is equipped with a special return spring and an eddy current damping device, and this movement operates quite independently of the operation of the oil relay. By means of these two return movements and the sector resistance which is in series with the armature of the rotary magnet and connected to an auxiliary source of current, all parts of the control gear work in unison, so that any one position of the automatic regulator corresponds to a certain position of the oil piston, and hence to a definite position of the induction regulator. If necessary, it is always possible to change over from automatic to hand operation, irrespective of the position of the oil relay piston.

As in the case of the electro-motor operated induction regulator, it is possible to compensate the pressure drop in the secondary circuit automatically by means of the regulating system described, together with a

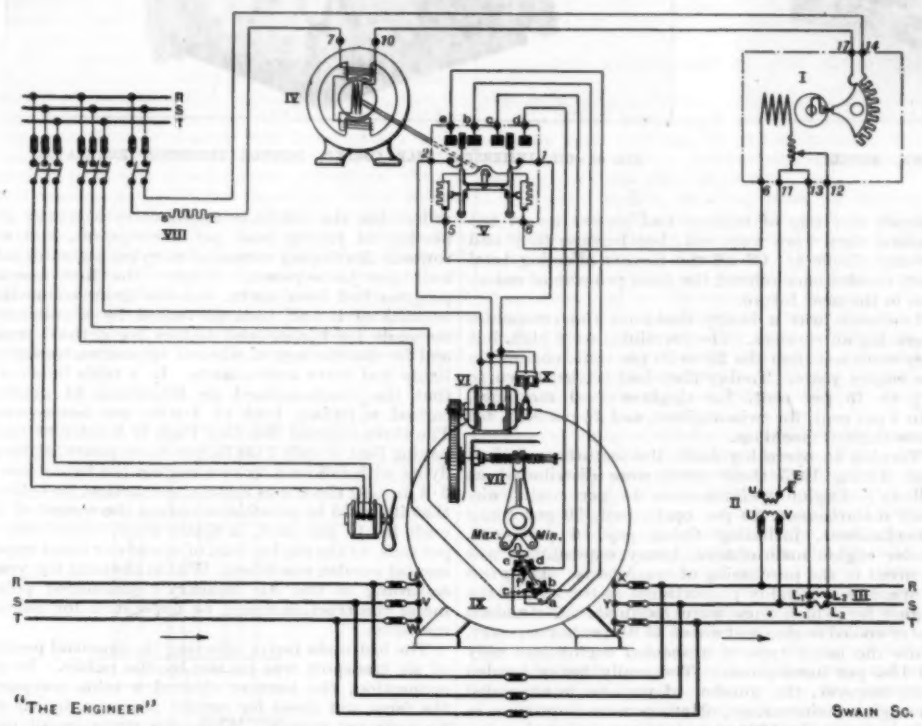

FIG. 38—CONNECTIONS FOR AUTOMATICALLY-CONTROLLED INDUCTION REGULATOR—BROWN, BOVERI

suitable current transformer which increases the regulation of the feeder pressure by the necessary amount in proportion to the load. It is also possible by means of an adjustable arrangement in the regulator to alter the pressure that is to be kept constant within the limits of 0–15 per cent. of the normal pressure.

A Brown-Boveri double induction regulator with air blast cooling fans and electric motor control is shown in Fig. 41. It is designed for three-phase, 50-cycle current and the primary and secondary windings are not connected with each other. The primary and secondary pressures are both 1000 volts. The actual power of the regulator is 382 kilovolt-ampères. The regulator is used in connection with two intermediate transformers for voltage regulation on a power transmission line carrying 4000 kilovolt-ampères. The regulator compensates for the fluctuations of the incoming pressure, which varies between the limits of 47,000 and 56,000 volts, the outgoing pressure being kept constant at 51,500 volts. An induction regulator of the same make and with air blast fans, but designed for hand wheel control, are shown in Fig. 40, the primary and secondary windings in this case being connected with each other. The incoming pressure is 390–460 volts and the outgoing pressure 228–572 volts. The power passing through each regulator is 20 kilovolt-ampères at 572 volts on the regulated side and the actual power of each regulator is 8 kilovolt-ampères.

A Brown-Boveri oil immersed self-cooled double induction regulator of the vertical shaft type with electric motor control is shown in Fig. 42. The regulator is designed for three-phase, 50-cycle alternating current at an incoming pressure of 10,000–11,000 volts, the outgoing pressure being 10,000–12,000 volts. The power passing through the regulator is 4700 kilovolt-ampères at 12,000 volts on the regulated side and the actual capacity of the regulator itself is 850 kilovolt-ampères.

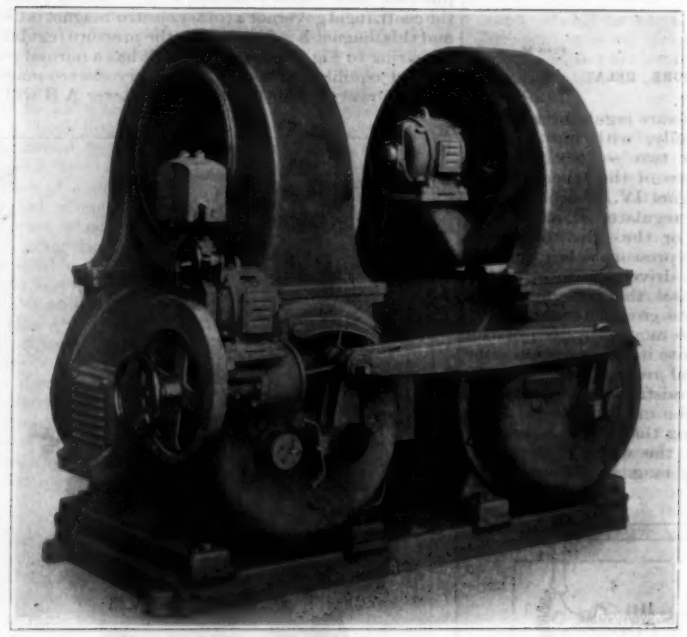

FIG. 41—DOUBLE INDUCTION REGULATOR—BROWN, BOVERI

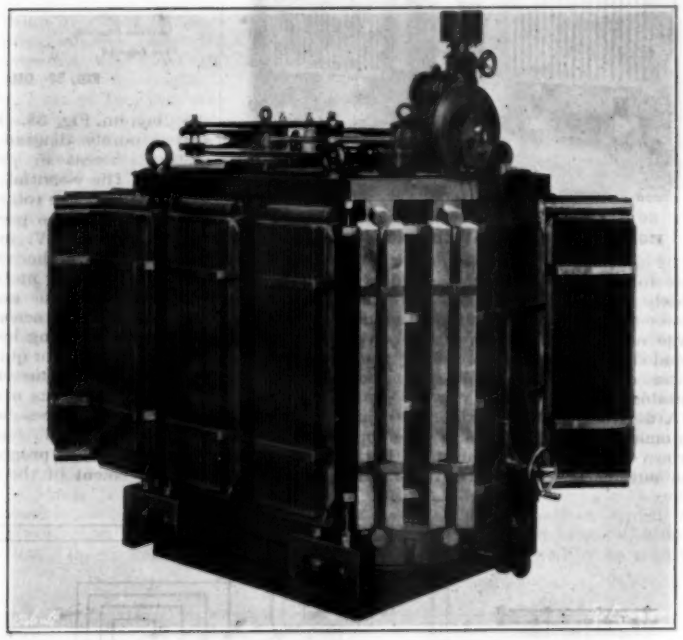

FIG. 42—OIL-IMMERSED, SELF-COOLED, DOUBLE INDUCTION REGULATOR

Air Transport.

DURING 1925, throughout the world's organised air routes, totalling 31,000 miles in length, the flights undertaken aggregated 14,382,900 miles. Yet in no case, within Europe at all events, has air transport paid its way. It has existed only by the grace of subsidies.

In the fifth Gustave Canet Lecture, which Air Vice-Marshal Sir W. Sefton Brancker delivered on Friday, April 30th, before the Junior Institution of Engineers, the unprofitableness of air transport as at present conducted was fully admitted. The factors affecting the prevalent lack of commercial success were, however, analysed, and it was in general concluded that improvements in sight or probable would in the near future result in placing air transport on a sound commercial footing, and make it independent of Government subsidies.

From May, 1919, to the end of 1925, thirteen paying passengers were killed and five were injured, as the result of accidents on recognised British air transport services. During 1925, of 4086 flights started, 58, or 1·4 per cent. of the total, were not completed. In addition, however, 932 scheduled flights were, for various reasons, not begun. Sir Sefton Brancker, in laying these figures before his audience, remarked that while proved safety and reliability would contribute largely towards financial success, the measures taken to ensure safety and reliability often tended to increase the costs of operation and therefore made for slow progress.

The total cost of carriage by air is about 5s. per ton-mile at 90 miles an hour. This figure, Sir Sefton admitted, was very high for the transport of freight and passengers, and could be accepted as a legitimate charge only for the carriage of first-class mails at high speed. The predominant factors affecting the financial aspect of the problem were, he said, divisible as follows:—(*a*) Overhead charges, viz., interest on capital, obsolescence and depreciation, insurance; (*b*) operating costs, viz., maintenance of engines, maintenance of aircraft, fuel; (*c*) revenue, viz., paying load per horse-power and volume of traffic.

Dealing with the first item (interest on capital), Sir Sefton remarked that the most effective way of reducing its effect on the problem was to increase the work done by each unit of the fleet. In a well-organised air service a machine should be able to spend 2000 hours a year in the air on day flying. On the average, 1000 hours a year was to-day considered good.

Depreciation could not as yet be assigned a fixed rate. It was not, however, nearly so serious a factor as obsolescence. The two together were frequently taken at 20 per cent. per annum, but this rate was not sufficient to meet the constant flow of improvements in design. Since 1919 two generations of aircraft and one of engines had passed away, not because they were worn out, but because they had become obsolete. Of all the factors affecting total cost, obsolescence offered the least promise of reduction in the near future.

Insurance was a heavy drain on the companies operating air services. The premiums were high, but they were less than the 20 to 30 per cent. charged in the earlier years. To-day they had settled down to 12½ to 15 per cent. for single-engined machines, 8 to 9 per cent. for twin-engined, and 7½ per cent. for three-engined machines.

Turning to operating costs, the lecturer remarked that during 1925 these costs were distributed as follows:—Engine maintenance, 44 per cent.; aircraft maintenance, 20 per cent.; fuel, 30 per cent.; miscellaneous, including flying pay, 6 per cent. Under engine maintenance, heavy expenditure was incurred in the purchasing of spare parts. The price of spares was roughly proportional to the cost of the engine for which they were required. A standard water-cooled engine cost about £5 9s. per horse-power, while the latest type of air-cooled engine cost only £3 15s. per horse-power. The really heavy burden was, however, the number of man-hours expended on engine maintenance. Matters were improving in this respect. In 1924 a certain type of engine frequently ran 210 hours before requiring overhaul. To-day this time had been increased to 250 hours, but a still better performance was required before real economy could be achieved. Analysing the principal defects which led to the removal of engines from aircraft belonging to Imperial Airways in 1925, he stated that valve breakage accounted for 31 per cent. of the total, defects in the water system for 20 per cent., failure of material for 19 per cent., deterioration of bearings for 12 per cent., defects in the oil circulating system for 10 per cent., and miscellaneous and indefinite defects for 8 per cent. Given patience, money, attention to detail and perhaps a little addition in weight, the lecturer could see no reason why the engines of the immediate future should not run for 500 hours without overhaul, and be free from at least half the defects stated above.

On the next item, maintenance of aircraft, Sir Sefton made the, at first sight, surprising statement that our standard type of aircraft, a biplane constructed of wood and fabric with interplane struts and wires, probably needs more attention than almost any other type. Such machine had, he said, flown for eighteen months, equivalent to 2000 hours in the air, without overhaul. He believed, however, that an all-metal, thick-wing monoplane without wires or struts would require much less attention and that it would fly for much longer periods without overhauling.

Fuel and oil were very big items, and in the present condition of the world's oil trade it would be unwise to trust to any reduction in the cost of high grade spirit. The development of the heavy oil engine for aeronautical duties was going on steadily. Although such engines were appreciably heavier than petrol engines, they saved a considerable weight of fuel burnt per horse-power hour, and for long flights it was possible that the saving in fuel might outbalance the additional weight of the engine. Furthermore, the reduction in the cost of the fuel would, of course, be enormous.

Passing to the revenue side of the problem, Sir Sefton said that designers must strive towards reducing the weight of construction of aircraft in order that the machines might carry a greater proportion of paying load per horse-power, and also towards developing means of carrying a greater total load per horse-power. Under the first heading progress had been made, but the direct commercial benefits of it had been prevented by simultaneous demands for higher load factors for a third engine and for the carriage of wireless apparatus, navigation lights and extra instruments. In a table he showed that the single-engined de Havilland 54 machine carried a paying load of 4·0 lb. per horse-power. The three-engined Handley Page W 9 machine had a paying load of only 2·56 lb. per horse-power, although flying with full load on two engines the figure rose to 3·8 lb. By the use of metal construction, he believed that it would be possible to reduce the weight of aircraft by 15 per cent., a figure which would add 42 per cent. to the paying load of one of our latest experimental wooden machines. Within the next few years, according to the Air Ministry's announced policy, metal construction would be imperative for military machines.

The last main factor affecting the financial position of air transport was its use by the public. In this connection, the lecturer showed a table comparing the fares and times for certain journeys, by air and by ordinary means. While the times in all cases were less by air, the fares were without exception greater. The extra cost of air transport averaged about 5s. for each hour saved on the journey.

To-day, Sir Sefton concluded, there was no great market for commercial aircraft, because air transport could not pay its way. But the world was waiting for air transport, and when it could operate on a really commercial basis, the demand for aircraft would be enormous. It was of the utmost importance that this country should be ready to supply that demand and to operate British aircraft in every part of the world.

Some Notes on Swiss Hydro-Electric Supply.

By ALFRED R. SIEVEKING.

THANKS to the courtesy of the Entreprises Electriques Fribourgeoises, the author was recently permitted to visit the power stations of that company and to study their working.

The area covered is shown in the accompanying sketch map—Fig. 1. Part of the power, it should be

FIG. 1—MAP SHOWING POSITIONS OF GENERATING STATIONS

added, is sold to France, and the district covered by that supply is not included in the map. It will be seen that there are four generating stations, of a total actual capacity of 53,900 horse-power, made up as follows:—Montbovon, 6400; Broc, 24,000; Fribourg-Oelberg, 7500; Hauterive, 16,000.

The only important town in the area is Fribourg, with some 100,000 inhabitants, hence the system is essentially a rural one.

Montbovon.—Montbovon was first visited. It is the smallest and the oldest station, having been constructed in the late nineties. The equipment consists of four 1100 horse-power, one 500 horse-power and one 1500 horse-power Girard turbines working under a head of 200ft., with a suction head of 20ft. The turbines are coupled to vertical alternators, giving 3-phase power at 8500 v., 50 cycle, and designed for ·8 power factor. The only set of modern design is that developing 1500 horse-power, which has just been installed. The alternators are separately excited from two direct-current generators, each of 600 ampères and 150 volts driven by Pelton wheels. As the total exciting current required is 200 ampères, there is ample reserve. Each group has its own switchboard for starting and paralleling, mounted opposite to it. When once the machines are paralleled all further regulation is carried out from a board midway between the others. The method of protection here, as in all the stations, is balanced current.

Transmission is carried out at three different

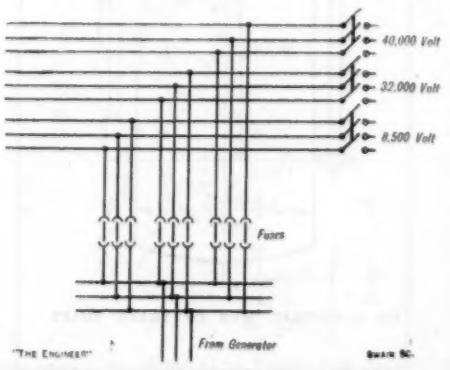

FIG. 2—BUS-BAR SYSTEM AT MONTBOVON

voltages—8500 for local use and 32,000 and 38,000 (later 65,000) for long distances. In order that any generator may be put on any feeder, the bus-bar system—Fig. 2—appears somewhat uneconomical of space, but it is as simple and compact as the circumstances permit. For voltage transformation two transformers are employed, one 8500–32,000 v, 1900 kVA star-star, and one 8500–38,000 v, 7000 kVA star-delta, later to be changed to star-star. From the respective bars current is led into a separate building on two floors, which houses the static dischargers (water jet type), lightning arresters (horn gap and choke coil in series), and feeder oil switches. From this building four 8500 v, two 32,000 v, and one 38,000 v feeders radiate. The main districts served are Pays d'Enhaut, Jaman, Gruyères, the Montreux railways, Romont and Châtel St. Denis.

About two miles from the power house a dam has been built to raise the head, the storage produced being negligible. It is 19ft. high and is built up of wood. The centre of the pipes is 12ft. from the bottom, and after passing through a screening house the water is carried through iron pipes, 3ft. in diameter, straight to the power house. The maximum flow at this part of the river is about 775 cusecs and the average about 670 cusecs.

Since this is such an old station a number of defects are obvious. For example, the static dischargers are mounted on each set of bus-bars, whereas it would have been the better practice to mount them in each set of lines. Furthermore, the feeder oil switches are mounted so close together that no repairs can be carried out on one without shutting down the feeders on either side; and, in addition, flash-over from one to the other is more than possible with the very small clearances allowed.

Broc.—Broc was next visited. This station is the exact antithesis of Montbovon, being the most recent and up-to-date of those visited. It has four 6000 horse-power Francis turbines with provision for a fifth. The stations of the company, apart from Broc, are tied in to form a ring, but it was found even when power was pooled that long-distance customers could not always be catered for; in consequence, Broc was erected. It may therefore be defined as a long-distance, high-voltage "helper" station.

The turbines, made by the Ateliers de Constructions Mécaniques, of Vevey, work under 400ft. head, with a suction head of 17ft. The alternators are vertical three-phase, 50-cycle, 500 revolutions per minute, ·8 power factor machines of modern Oerlikon make. The hot air from these machines is led away through four ducts, and in winter is fed into the power house to warm the building, while in summer it escapes from a pipe leading to the roof. Each alternator has its own exciter mounted above it, and driven by an extension of the main shaft. The maximum excitation required is 350 ampères at 80 volts, and the exciters have sufficient reserve, being built for 400 ampères at 80 volts.

Since only high-voltage distribution is made from this station, the bus-bar system is less complicated than in most stations, and as the voltages used are 38,000 and 65,000, a transformer so constructed that its secondary can be either meshed or starred from

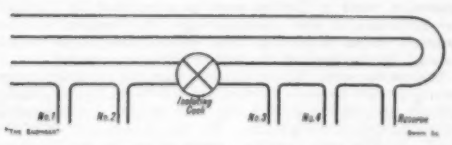

FIG. 3—PIPE ARRANGEMENT AT BROC POWER STATION

the outside is sufficient; hence in this station a generator and transformer act as a unit, separated only by knife switches, all switching being done on the high-tension side. Incidentally, this arrangement reduces the spare plant required.

The main feeders radiating from the station are three:—A 65,000-volt, 110-mile line to France; a 38,000-volt, 60-mile line to the Valais; a 38,000-volt, 30-mile line to Hauterive. These are the main feeders, but facilities are provided to feed power to Montbovon and to Hauterive, *via* Romont or Corbatières, as well as directly, to provide for line accidents. Since there are only four machines in the station, with one usually acting as a stand-by, paralleling of two machines is very rare. Again, the directions and line lengths being so different, two sets of 38,000 volt bars are used.

The switching of the station is carried out from one point, and can easily be done by one man. In the middle of one wall of the alternator room is a recess with a slightly raised platform approached from either end by four steps. Along the side of the platform nearest the machines desk type starting panels for the four sets are mounted. On the opposite side are nine vertical panels of normal type; they are feeder and house panels. All high-tension gear is mounted immediately behind the generator room. The arrangement is carried out on two floors. On the upper are the transformers belonging to each unit, the lightning arresters, induction coils, and water jet static dischargers; below are the feeder oil switches, bus-bars, departing lines and instrument transformers. Each piece or group of pieces of apparatus is isolated from the other by brick partitions or wide gangways.

About 1¼ miles from the power house a dam has been built across the river Jogne, forming the artificial Lac de Montsalvens. Built in an arc of a circle of reinforced concrete, the dam has a total height of 150ft. The depth below the surface of the tunnel intake is 85ft. When full the lake contains about 390 million cubic feet of water. The water is carried to the power house, first through a mile-long tunnel, 70 square feet in cross section, and then through two iron pipes, ¼ mile long, and each of 45 square feet cross section. The pipe arrangement at the power house itself—see Fig. 3—was chosen to minimise the loss of head from one turbine to the next, by virtually making the head work two turbines.

An interesting feature here is the power factor of each line. That to France is bad, about 0·6, as the consumption is on induction motors; that to the Valais is good, about 0·9, as it feeds furnaces; while the remaining lines work at about 0·8. These are widely varying power factors, and to counteract the effect on the machines, which are designed for 0·8, it is usual to change over periodically those supplying at 0·9 and those at 0·6.

Hauterive.—Following the windings of the Sarine some 30 or 40 miles Hauterive station is reached. It is a fairly old and small station, but it has two interesting features, for it has the only large outdoor transformer station in the system and contains the only generator of any magnitude, one of 10,000 horse-power.

The three buildings and the outdoor transformer station of which it is comprised stand in a quadrilateral. The main building houses three 1200 horse-power Pelton wheel driven alternators, two 1200 horse-power Girard turbine alternators, one 10,000 horse-power Francis turbine alternator. Of this very mixed lot the Girards have proved the least suitable for the conditions. The head being about 200ft., the Pelton wheels and Francis turbine are giving good service.

Excitation is carried out from one or other of two alternative sources—a Girard turbine-driven 500-ampère, 120-volt, direct-current generator, or a 300-ampère, 120-volt, direct-current generator driven by a 500-volt alternating-current motor. The excitation current required is 350 ampères, so the motor-driven machine is kept as a stand-by. There are two transformer houses. In one are housed two ancient and noisy transformers of 2500-kilowatts, 8500–32,000 volts, and two house transformers of 30 kilowatts. All these are shortly to be replaced by new and more efficient machines.

In the other and larger transformer house there are two floors. On the lower is situated a 10,000 horse-power transformer, which is only used in conjunction with the 10,000 horse-power generator, while on the upper floor are the 32,000-volt departures with the necessary lightning arresters, condensers and choke coil, water jet static dischargers and feeder oil switches, remote controlled. Next to this house is the outdoor transformer station, which has a 3400 horse-power, 8500–65,000-volt transformer, instrument transformers, oil switch and lightning arresters. This station, used with any machine at Hauterive except the 10,000 horse-power, is the original starting point of the French line; now, however, Broc is the more important starting point, and this transformer station, together with the 10,000 horse-power unit, is tied in with the Broc line.

Switching is all carried out in the main building, where each machine has its own starting and paralleling board. In the centre at the back, and somewhat raised above the rest of the floor, are the feeder control boards. Transmission is carried out at 32,000 volts to Fribourg, tying in with the Broc–Hauterive line, and 65,000 volts to France; consequently, only two sets of bars are necessary.

The dam is 5 miles away, and is of reinforced concrete about 100ft. high. Like that at la Tine, it is only built for raising the head, the storage being very small. The water is carried through a 4½-mile tunnel, 160 square feet in cross section, and, finally, through ¼ mile of iron pipe line, 20 square feet in cross section.

This station suffers from many of the defects that were noticed at Montbovon, notably in its feeder oil switches being too close together, and the lightning arresters not functioning properly. At the time of visiting it the changes to switchgear were well in hand, and completion was expected by the end of last year. The new brick and cement cubicles will be a big improvement on the old partitionless, skeleton truck type gear. The condenser arresters were also being scrapped, as they were found unsuitable for their purpose—an interesting point, since those at Fribourg are very successful. Improvements were also being effected in transmission line arrangements. Previously the lines were at an angle with the building, and it was found that the spray from a neighbouring waterfall, together with the snow in winter, caused frequent shorts. It is to overcome this objection that the lines are now being arranged to depart from the building at right angles.

Fribourg-Oelberg.—The final station visited is situated in the town of Fribourg, and since it is only built to supply that town it will not be described in great detail. The Sarine has now travelled about 60 miles since Montbovon and is therefore a river of large volume. As a result, Francis turbines working under the low head of 60ft. are used.

There are three 2500 horse-power machines, each requiring 640 cusecs. In common with the rest of the system, generation is at 8500 volts, 50 frequency, three-phase. Excitation is supplied either from a motor-driven or Francis turbine-driven direct-current generator. The maximum required is 320 ampères, 220 volts, and either source can supply it for as long as it is required. There is one 3400 horse-power, 8500–32,000-volt transformer, which gives the excess energy of the station to Hauterive. Apart from this, all power is generated at 8500 volts, and is used in the town.

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Switching is simple. Each machine has a desk type board for itself, while in the corner of one end of the machine floor is a slightly raised platform, on which is the direct-current control board, again desk-type, and 8500-volt vertical feeder panels at the back. The 32,000-volt control is carried out from a desk-type panel situated on the machine level, and just next to the aforementioned platform. The lightning arresters are condensers, here very successful; and choke coils in the 32,000-volt lines.

A 60ft. dam a furlong away forms an artificial lake of moderate storage capacity, and the water is carried along a canal and then through iron pipes, one pipe per machine.

Certain features are common to all stations. Thus, all structural work, except the la Tine dam, is carried out in reinforced concrete, which harmonises singularly well with the countryside. With the exception of distribution at the station and on the 65,000-volt line, transmission is carried out entirely on wooden poles. The author was given to understand that all the stations had been constructed as cheaply as possible, but there appeared no signs of rough work except on the transmission lines. These lines, to British engineers, would appear exceedingly dangerous. Much of the ground between the stations was covered on foot, and an opportunity was thereby offered of examining the transmission system. Only occasionally are two poles used at crossings. The lines have to be kept a certain distance, 10ft., away from light power lines, but, apart from that, no slings or other precaution is in use when crossing. What appeared particularly dangerous is the method of carrying the 8500-volt wires along the side of the Montreux Railway. This is a mountain railway, and at times runs through rocky cuttings parallel with and close to the road—so close, in fact, that the passer-by could easily stretch out his hand and touch an 8500-volt alternating-current line and sometimes an 800-volt direct-current line.

Electricity is used for both power and lighting. Transformer cabins are placed at strategic points, and from them run lighting lines, four-wire, 220-volt, line-star point, and power wires, three-wire, 400-volt, line-line. Choke coil and horn gap arresters are placed on the pole of the high-tension line immediately preceding the transformer cabin. There are none on the low-tension line.

This power system shows in an interesting way how a careful use of one river can provide light and power economically over a large area. A curve of the monthly output for one year is shown by Fig. 4.

FIG. 4—OUTPUT CURVE

The interesting point to engineers used to temperate climates is the curious position of the maximum and minimum peaks. Thus the minimum is during the winter when the river is ice-bound, and the maximum in summer and early autumn, when rain and melting snow combine to keep up the head of the river and its quantity. The figure for May is a curious one. It is low, owing to the fact that throughout the month there was a bad drought, and yet it is kept fairly high by the thaws taking place in the mountains.

Bending and Torsional Strains and Stresses in a Loaded Crank Shaft.

By H. CARRINGTON, B.Sc. (Vict.), M.Sc. (Tech.), A.M.I. Mech. E.

IN the absence of more rigorous methods of calculating the bending and torsional strains and stresses in a loaded crank shaft, resort has to be had to the ordinary theories of bending and torsion as applied to long beams and shafts. In applying these theories to a crank shaft, the question naturally arises as to the degree of error involved, for the strains in the webs, pins and journals may not satisfy the theories because of the influence of the end conditions at the join of the webs with the pins and journals where the strains are probably of an involved nature. With the object of giving an indication of any errors so introduced, some of the strains in an actual crank shaft loaded in various ways were measured.

The crank experimented upon was of the four-throw type, for use in an engine giving 30 brake horse-power at 1500 revolutions per minute, the probable maximum thrust on each pin being 3200 lb. at between 15 deg. and 20 deg. from the dead centre. The crank was sawn across the mid length of the central journal, and thus formed two similar two-throw cranks. One part was made into test pieces, and the other—which is shown in Fig. 1, with the leading dimensions—was used in the experiments.

Method of Measuring Strains.—For the first series of experiments the ends of the crank were slotted to fit the jaws of an Avery 12,000 lb. in. torsion machine and the strains were determined corresponding with a torque of 4000 lb. in. The methods used for the measurement of the strains in this and subsequent experiments were largely based on the use of Martens' extensometer. It is perhaps not necessary to enter into detail as to these methods in all cases, and only that used for the central web when the crank was twisted about its longitudinal axis will be described.

Fig. 2 shows the central web looking in the direction of the longitudinal axis of the crank with Martens' blades B B in position and the rockers R R at opposite ends on the two sides.

When the crank was twisted the readings indicating the tilt of the rockers, and hence the changes in length on the two sides, differed, and it will appear that the difference was proportional to the sum of the changes in length

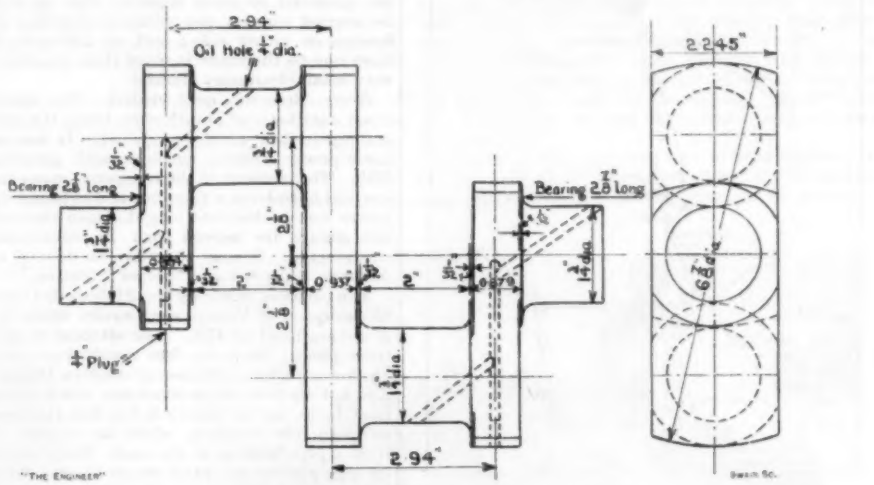


FIG. 1—PORTION OF CRANK SHAFT USED FOR EXPERIMENTS

on the two sides of the web, any bodily rotation of the crank being eliminated. When one blade was reversed so that the rockers were both at the same end of the web, the readings were the same. From these observations it was clear that there was no uniform change in length of the web, and that the extension on one side and shortening on the other were equal. The values of the shortening and extension were evidently each proportional to one-half the difference in the readings when the rockers were at opposite ends. Knowing these values, the angle turned through by the ends of the web could be calculated.

The values were obtained from graphs of readings corresponding with torques varying by 400 lb. in. up to usually 6000 lb. in., the angles being calculated corresponding with a torque of 4000 lb. in. For the determination of the strains at the mid-length of the web blades 0·55in. long were used. In all the experiments the methods used for measuring the strains were so devised that any bodily rotation or motion of the crank was automatically eliminated in the readings.

Results of Torsion Experiments.—The results of the torsion experiments are given in Fig. 3.

In the table the second row gives the angles turned through by the portions of the crank indicated in the first row corresponding with a torque of 4000 lb. in. In the third and fourth rows are given the couples and stresses respectively calculated by the ordinary theories of bending and torsion from the results in the second row, using the moduli as determined by experiments on test pieces cut from the other half of the crank, *i.e.*, Young's modulus $= 29{\cdot}6 \times 10^6$ lb. per square inch, and the modulus of rigidity $= 11{\cdot}85 \times 10^6$ lb. per square inch.

From an examination of the results the following conclusions can be drawn, it being borne in mind that the presence of the oil holes will tend to make some of the measured strains and the corresponding couples and stresses slightly higher than they otherwise would be.

(1) The measured couples in the side webs are slightly less than the applied couple, probably owing to the stiffening effect of the crank pins and journals.

(2) The measured couple in the central web is the same as the applied couple.

(3) The measured couples in the crank pins are the same as the applied couple.

(4) The relative motion of the journals is negligible, being of the order of 10^{-6}in. It would be much greater if the crank were of the single-throw type, in which there is no central web, and were subjected to a pure torsional couple as in this instance, for the relative motion would then be of the order 10^{-3}in.

(5) The twist in the whole length of the crank, *i.e.*, from A to F, is $28{\cdot}8 \times 10^{-4}$ radians, whereas the twist in a shaft of equal length and of the same diameter as the journals, *i.e.*, 5·88in. long and 1¾in. diameter, would be somewhat less, being $21{\cdot}6 \times 10^{-4}$ radians. This fact may be of importance when dealing with torsional oscillations.

In addition to the above observations, it was found that bend in the crank pins and twist in the webs about their longitudinal axes was inappreciable.

Results of Bending Experiments.—In the bending experiments the crank was supported in vee blocks in which piano wire, $^1/_{16}$in. diameter, had been soldered, in order to form hard and slightly rounded knife edges, the span being 7·66in. The crank was first loaded, as shown in Fig. 4, which also contains a table giving the results of the experiments.

The first row in the table indicates the portions of the crank in which the strains were measured, it being assumed that the strains in the symmetrical portions were equal. The second row gives the twists about the longitudinal axes of the webs and bend in the crank pins, with the exception of the last figure, which refers to twist in the crank pins about their longitudinal axes. The third and fourth rows contain the couples and stresses calculated from the results in the second row by the ordinary theories of bending and torsion, whilst the fifth row gives the applied couples. All the results correspond with a central load of 3765 lb. or torques in the crank pins of 4000 lb. in. From a consideration of the results, it will be evident that—

(1) The measured torsional couple in the side web is appreciably less than the applied couple. This is probably owing to the stiffening effect of the crank pin and journal. A similar effect was indicated in the torsion experiments—Fig. 3—but in a less degree.

(2) The measured torsional couple in the central web is nearly the same as the applied couple.

(3) The measured bending couple in the crank pin is appreciably less than the applied couple.

(4) The measured torsional couples in the crank pins are the same as the applied couple.

The stress given in the portion c^1–d^1 of the central web, i.e., 13,000 lb. per square inch, is the torsional stress in the middle of the long side of the cross section. It was calculated from—

$$T = \frac{a\,b^2}{3 + 1{\cdot}8\,\frac{b}{a}} f^* \quad \cdots \quad (1)$$

where T is the measured couple, a and b the lengths of the long and short sides of the cross section respectively, and f the stress. The stress in the middle of the short side can be obtained from—

$$T = \frac{a\,b^2}{2{\cdot}15 + 2{\cdot}4\,\frac{b}{a}} f \quad \cdots \quad (2)$$

This formula was deduced from St. Venant's researches

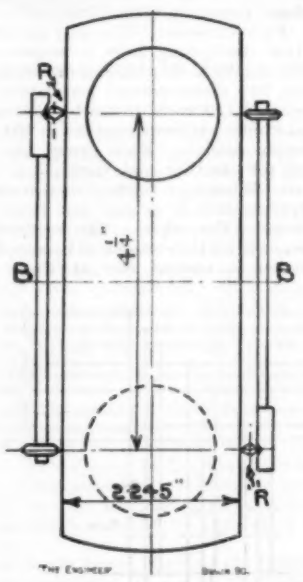


FIG. 2—CENTRAL WEB OF CRANK SHAFT

on torsion†, and gives f as 10,900 lb. per square inch. Both these formulæ introduce errors which, however, are less than 5 per cent. for all values of the ratio $\frac{a}{b}$ in formula (1) and provided $\frac{a}{b} > 1{\cdot}25$ in formula (2). The error introduced by both formulæ in the case of the central web is about 4 per cent. The stress given by formula (2) may be important, if bending is present, for the resultant stress in the middle of the short side may then be greater than the torsional stress in the middle of the long side. It may

* "Strength of Materials," Morley, Art. 112.

† "Theory of Elasticity," Todhunter and Pearson, Vol. II., Part 1, Art. 47.

be noted that when the crank is loaded as in Fig. 4, there is no applied bending moment on the central normal cross section of the central web.

In addition to the strains given in Fig. 4, strains corresponding with twist about the longitudinal axis of the crank, *i.e.*, about the line A F, were measured, and were as follows:—

	A—B, E—F.	B—C, D—E.	C—D.	A—F.	*c—d.*
Twist (10^{-4} rad)	1·275	8·62	3·91	23·7	8·48

It is interesting to note in connection with these strains that the longitudinal axis of the web was convex towards the load. The shape of the axes of the crank was, in fact as shown in Fig. 3, with the longitudinal axis of the web C D convex towards the load.

In the second series of bending experiments the crank was loaded as in Fig. 5.

From an examination of the results it appears that—

(1) The measured bending couples in the left-hand and right-hand crank pins are appreciably less and greater respectively than the applied couples.

(2) The measured bending couple over the 1in. length of the central web is appreciably less than the applied couple, whereas the measured bending couple over the 0·55in. length is sensibly the same.

General Conclusions.—A general examination of all the results shows that for a crank of proportions similar to that shown in Fig. 1, the ordinary theories of bending and torsion applied to the central normal cross sections of the webs and pins give stresses which are either equal to or less than the actual stresses, except in the case of the right-hand crank pin in Fig. 5. There is, moreover, no evidence that the direct shear has any influence on the measured strains. In this connection it may be noted that, according to St. Venant, normal cross sections of a beam remain plane during strain if the shear is constant along its length. In the cases under consideration, where the crank is subjected to bending, the shear is constant between the points of support and of application of the load, so that in view of St. Venant's theory, any divergence from the ordinary theory of bending is hardly likely to be caused by the direct shear. The divergence in the case of bend in the crank pins is probably owing to influence of the end conditions. Any distortion of the webs is likely to cause a distortion of normal cross-sections of the pins so that the ordinary theory of bending does not apply.

From the usual theory of shear in beams the maximum shear stress occurs on the neutral planes of the side webs when the crank is loaded as in Fig. 4, being ½ of the mean shear stress,‡ or 2850 lb. per square inch. This is considerably less than any of the bending or torsional stresses measured. In view of this fact, and as the direct shear stress does not influence the bending and torsional stresses and is usually greatest where they are least, and *vice versâ*, the direct shear stress is probably only of secondary importance.

The results of a tensile test on a bar 0·564in. diameter, gave:—Yield stress, 27·75 tons per square inch; ultimate stress, 46·85 tons per square inch; elongation on 2in., 26·5 per cent.; reduction, 54·5 per cent. The mean of three Izod tests on a test piece of 1 cm. square cross section gave 4·2 foot-pounds. This Izod figure is very low, and taking it as an indication of brittleness, the material is unsuitable. Under the influence of alternating and suddenly applied loads, cracks may develop, especially at the junction of the webs with the pins and journals, where the strains are of a complicated nature, and may be excessive locally. There are many instances of failure of cranks at these junctions. It is evidently of importance to avoid the use of brittle material, particularly in view of the absence of any method of calculating the strains at the junctions.

The writer is indebted to Principal B. Mouat Jones, M.A., and to Professor G. G. Stoney, F.R.S., for permission to perform this research. He is also indebted to Belsize Motors, Ltd., for the gift of two machined crank shafts.

‡ "Strength of Materials," Morley, Art. 71.

	A-B E-F	B-C D-E	C-D	A-F	a-b	c'-d'	b'-c' (Bend)	b-c d-e (Twist)
Twist (10^{-4} rad)	3·50	7·00	37·8	58·8	1·215	12·7	1·47	3·90
Couple (lb. in.)	—	—	—	—	1,005	6,820	3,640	4,260
Stress (lb/sq in)	—	—	—	—	—	13,000	6,920	4,040
Applied Couple (lb. in.)	—	—	—	—	1,675	7,210	4,390	4,000

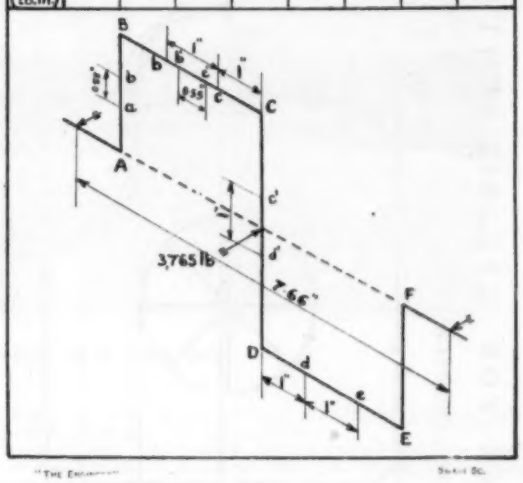


FIG. 4—RESULTS OF BENDING EXPERIMENTS

	b'-c'	c'-d'	c-d	d'-e'
Twist (10^{-4} rad)	1·49	11·05	8·97	2·27
Couple (lb. in.)	3,690	5,030	7,430	5,620
Stress (lb/sq in)	7,020	15,300	22,600	10,700
Applied Couple (lb/in.)	4,390	7,210	7,210	4,390

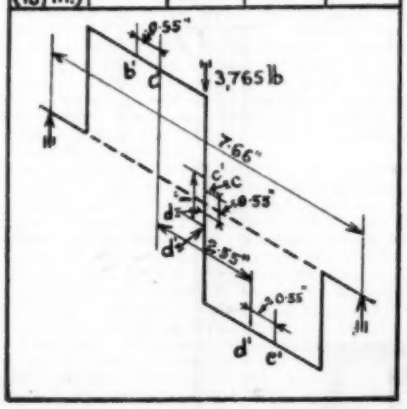


FIG. 5—SECOND SERIES OF BENDING EXPERIMENTS

Sewer Pipes Laid by Thrust Boring.

WE recently had an opportunity of inspecting two lengths of sewer pipes which have been laid by means of the Mangnall-Irving system of thrust boring. This system has for a number of years now been employed for such purposes as the running of pipes to contain, say, electric cables, under roadways, railways, &c., but the present is the first time that the method has been used commercially for laying pipes on strictly prescribed gradients. We may say at once that the operation was perfectly successful, the two pipes being laid to exactly the specified gradients.

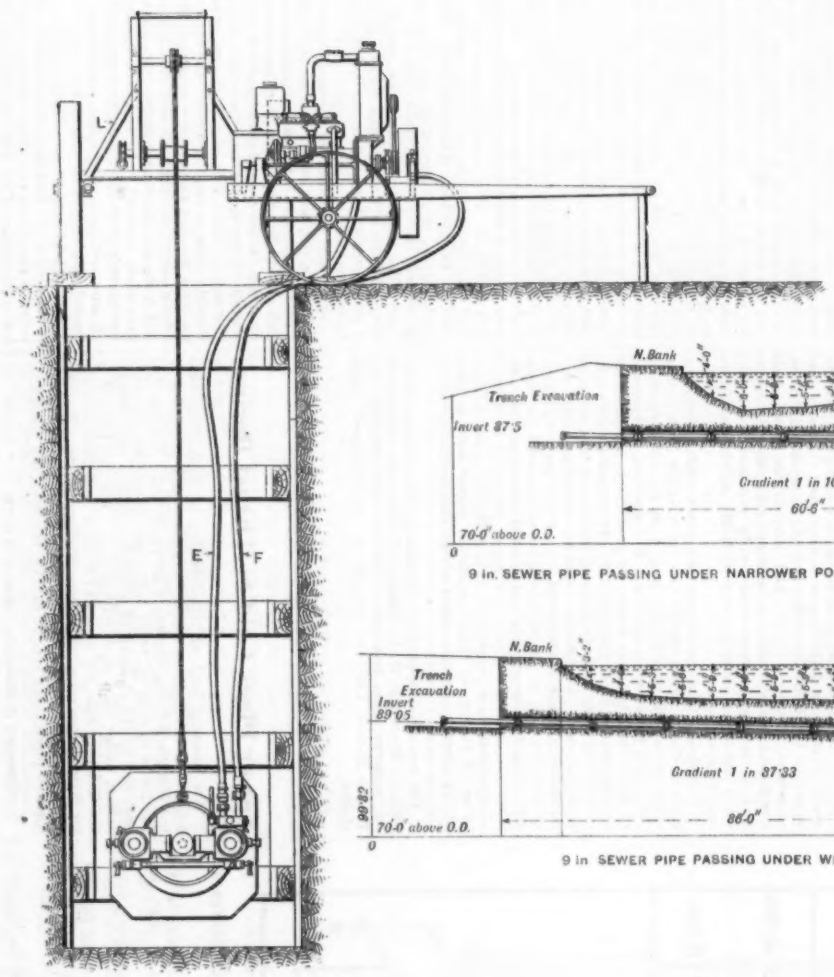
Our readers are already acquainted with the general principles underlying the process of thrust boring, for we dealt with it in our issues of April 9th, 1920, April 22nd, 1921, and March 10th, 1922. But we may here say, briefly, that it consists, first of all, of pushing a solid pilot head, of comparatively small diameter, from a pit dug at one side of the road or other obstacle to be crossed, until it comes out in another pit dug at the other side of the obstacle. This work is, of course, carried out in stages, additional rods being connected on in the rear of that carrying the pilot head as the latter is pushed forward by means of a specially devised machine. With the machine as originally introduced, when the pilot hole was completed, the pilot head, and its rods were pulled back in the direction from which they had come, and an enlarging head to increase the diameter of bore to the desired size was then pushed through. In an improved machine, a large size of which was used for the work with which we are dealing, when the pilot head has been pushed through into the second pit, it is disconnected, and an enlarging head designed to increase the diameter of the hole sufficiently to permit of the passage of the pipes which it is desired to lay, substituted for it. To the other end of this enlarging head is screwed a rod which has a thread cut on it at one end, and has a corresponding threaded socket at the other end, and which is of a length a little greater than that of one of the pipes. Over this rod is threaded a pipe, and then what is termed a thrust plate, which is of the same diameter as the pipe socket, and which is furnished with a central hole, is threaded over the projecting end of the rod and is clamped tightly against the end of the pipe by means of a nut. The enlarging of the pilot hole is then done by pulling and not pushing the enlarging head through it, so that to effect it the machine which was used to push or thrust the pilot head is made to work in the opposite direction, so that the enlarging head is made to travel towards the pit in which the boring was begun. This operation is done in stages of 3ft. each, and since the pipe is rigidly attached to the enlarging head, it follows immediately behind it into the enlarged hole. As each length of pipe is drawn in, the nut holding the thrust plate which is clamped against its end is unscrewed, the plate removed, another length of pulling rod screwed on, a further length of pipe threaded over it, and the plate clamped against its end, as in the case of the first pipe. The joint between the two pipes is then made, and the pulling machine again put in action. This series of operations is performed over and over again till the end of the leading pipe has reached the pit from which the boring was started. It will be understood, of course, that an armoured or otherwise protected cable can be drawn into the hole instead of a pipe. The inventors explain that one of the reasons why they pull the enlarging head instead of pushing it, is that a much greater load can be applied to it, since the rods are in tension.

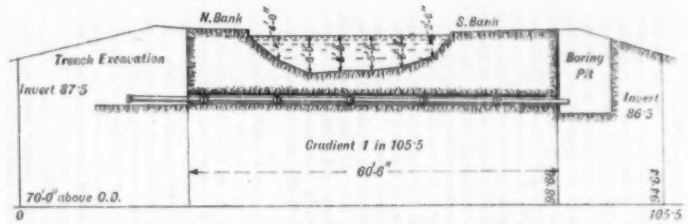
For such purposes as forming conduits for electric cables, or for, say, water service pipes, which are always under pressure, it is by no means necessary that the bored hole should be to an exact gradient, though it is, of course, desirable, in the case of cable ducts, at any rate, that there should be no depressions in which water might collect. For sewer work, however, it is essential that the pipe should follow an exact gradient, and it is the method which has been devised for ensuring that the pilot hole should be driven exactly to gradient that differentiates the machine which we are about to describe from those which we have previously noticed. As is by no means uncommon in engineering matters, the device employed, though it took an immense amount of experimental work to evolve it, is exceedingly simple in principle.

The two lengths of sewer pipes, to which reference was made above, are laid near Greenford, in Middlesex, where extensive work on new main drainage has been proceeding for some time under the supervision of the consulting

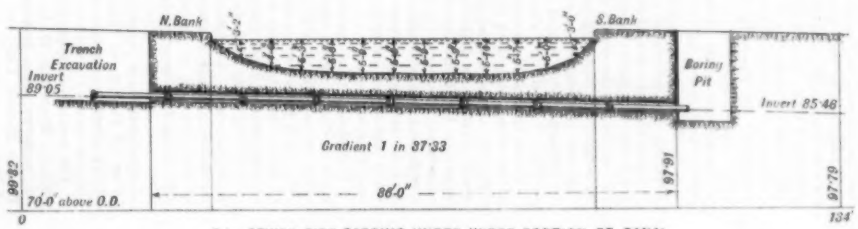
THE MANGNALL-IRVING THRUST-BORING MACHINE FOR LAYING SEWER PIPES

THE HYDRAULIC ENGINEERING COMPANY, LTD., CHESTER, ENGINEERS

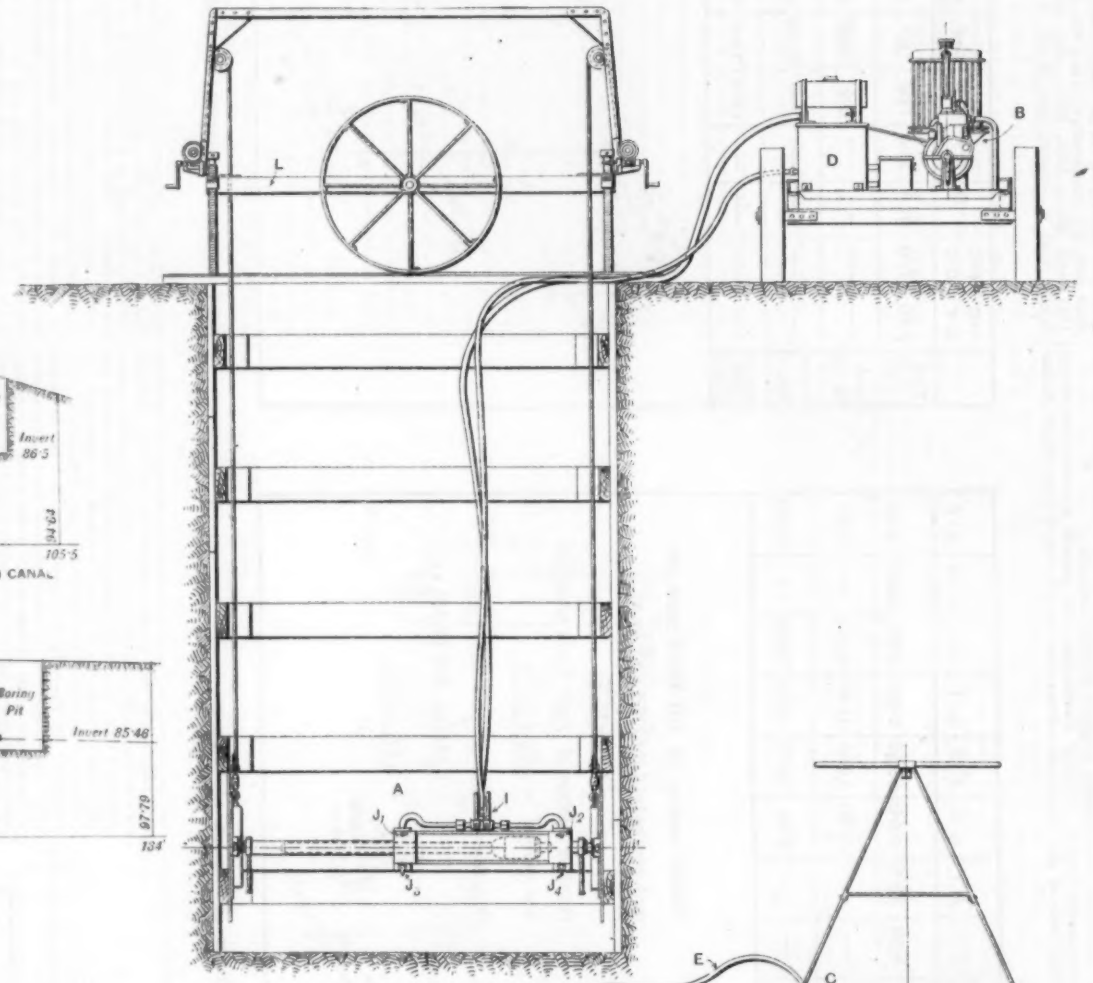


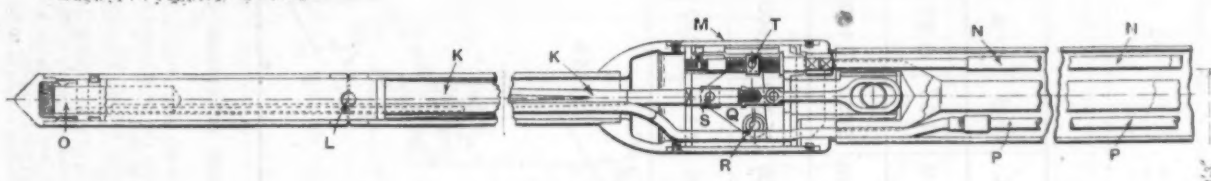


9 in. SEWER PIPE PASSING UNDER NARROWER PORTION OF GRAND JUNCTION CANAL

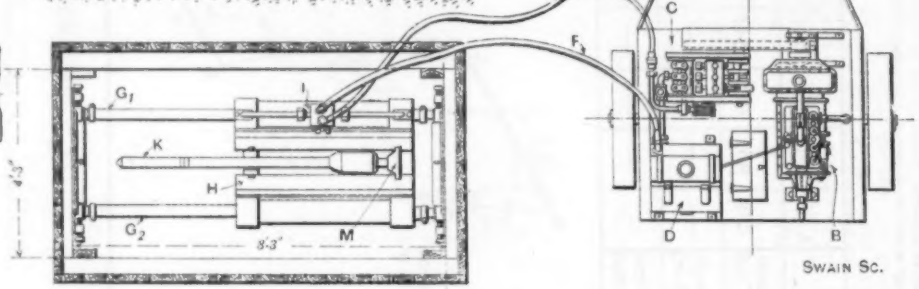


9 in SEWER PIPE PASSING UNDER WIDER PORTION OF CANAL





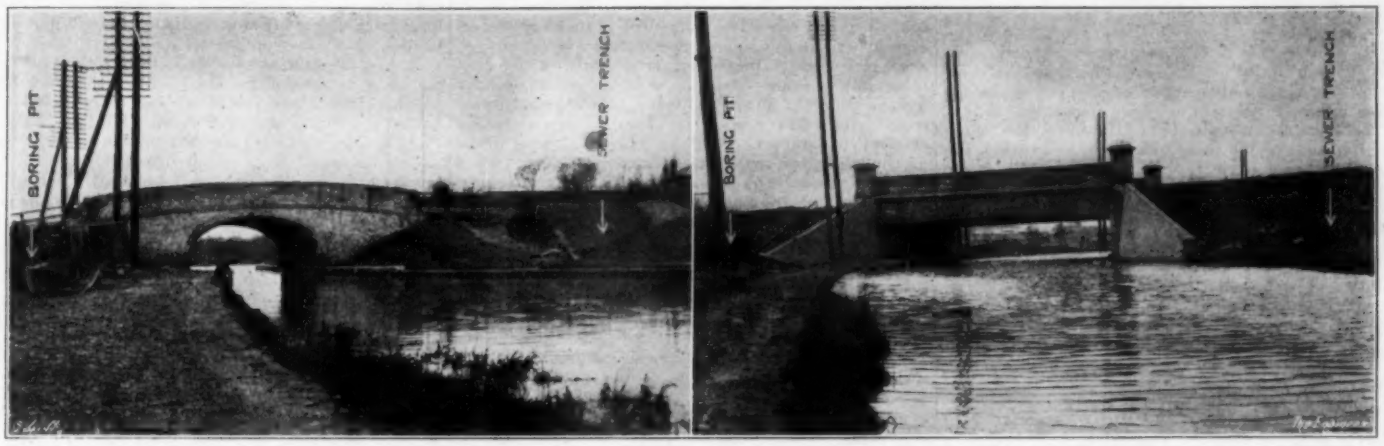
PILOT HEAD AND CONTROL GEAR



SWAIN SC.

"THE ENGINEER"

engineers to the Council. At two points in the main drainage system 9in. sewer pipes had to pass below the Grand Junction Canal, the direction taken by the pipes being approximately at right angles to the centre line of the waterway in each case. At the two points where the crossing occurs, which are shown in Figs. 1 and 2, the canal was 33ft. and 62ft. wide respectively. Had the work been carried out in the ordinary way, by excavation, it would have been necessary, in the case of the narrower crossing, to dam the full width of the canal, and that would have involved the entire closing of the canal to traffic, which in its turn would have entailed the payment of a no inconsiderable amount of money in stoppage



FIGS. 1 AND 2—NARROW AND WIDE STRETCHES OF CANAL UNDER WHICH PIPES WERE LAID

charges, for the Grand Junction Canal at this point is a very busy waterway, and along it a large quantity of house refuse—to mention one thing alone—is carried every day. In the case of the wider crossing, it would have been possible to dam off half the width at a time, which would have left just sufficient width for the passage of the barges. Both operations would, of course, have occupied a considerable amount of time, and have been very costly, and tunneling was considered to be impracticable by reason of the small amount of cover which there would have been between the top of the tunnel and the bed of the canal.

On consideration the consulting engineers decided to carry out the work by thrust boring. Short lengths of sewer pipe were laid by thrust boring as far back as 1920, but, of course, had to rely on the ordinary pilot for accuracy. The work at Greenford was therefore to be the first occasion on which the new pilot steering mechanism was to be employed. A point in favour of trying the system at Greenford was that the soil to be traversed was very hard yellow-blue clay, which is quite suitable for the purpose. It was just possible that stone might be encountered, and perhaps something was met with which slightly deflected the pilot in the longer of the two bores in the horizontal plane, for the receiving trench, which was only just wide enough to get the sewer pipes down and jointed, had to be widened, to permit coupling.

Now it is a curious fact that no matter at what depth a thrust bore is made—up to reasonable limits, at all events—the pilot would, were it only a plain bar, take the line of least resistance and make towards the surface. The ordinary pilot used for cable work and the like is so constructed in size and shape that this tendency to rise is compensated, and deviation in a boring is only very slight, as described in our issue of April 9th, 1920. When, however, it is a question of laying pipes to an exact gradient, accuracy in boring becomes of paramount importance. The inventors had always kept in view the possibility of their system being employed for the running of sewers, but it was not until they had devised a method of controlling the path taken by the pilot head that they felt that they could recommend it for such work. Judging from the success which has attended the operations at Greenford, it would appear that they have satisfactorily solved the problem, and, if that be so, then a very much wider field of applications is open to their system than it has hitherto enjoyed, though, it may be mentioned in passing, that it has been increasingly used for various purposes ever since it was first introduced.

The method employed for regulating the path taken by the pilot will be readily understood by a consideration of the drawing, at the bottom left-hand side of page 522, which is a section through a boring head and its controlling mechanism. In this drawing K is a central spindle, which tapers towards its rear end and which can pivot in a vertical plane at L, when it is caused to move up or down by the mechanism contained in the casing M, which is operated from the boring pit by means of the rod N. O is a small reservoir or chamber arranged in the forward end of the pilot head. It contains water, and is provided at its top at the front end with a small vent hole. This chamber is connected by a tube P right back to the boring pit, where it terminates in a vertical glass U tube fixed in front of a graduated scale. The scale itself is arranged alongside the borer at the forward face of the pit. The pipe and reservoir are, of course, filled with water before operations are commenced.

It will be evident that any tendency of the pilot head to deviate from the horizontal will at once be shown by an alteration in the level of the water in the vertical glass tube, since the level there must be the same as that of the reservoir of water in the pilot head. It will also be understood that if the scale be suitably graduated so as to represent the gradient at which it is desired that the pipe shall be laid, and if the level of the water be made by controlling the pilot head, as mentioned above, and referred to in greater detail below, to conform to the graduations of scale as the boring proceeds, a hole at exactly the desired gradient will be formed. It should be here explained that the construction of the apparatus is such that any tendency of the pilot head to revolve is prevented, and that, before starting operations, it is made certain that the pivot pin is accurately horizontal. Any movement of the pilot head must therefore be truly vertical, up or down. When the pipes are pulled through the enlarged hole, they, too, will lie at exactly the desired gradient, for we understand that the enlarging head will always exactly follow the line of the pilot hole.

Returning to the method of controlling the pilot head, it may be pointed out that the triangular member Q is pivoted at R to the case M containing the control gear, and is connected by the pin S to the spindle K and by the pin T to a threaded lug through which passes the screwed end of the control rod N. By turning the latter in one direction or other the pin S, and with it the rear end of the spindle K, will be moved up and down, and since the spindle K is in one with the pilot head, the latter will also be correspondingly moved down and up, pivoting on the pin L. There is just enough clearance left in the forward extremity of the bore of the tube enclosing the spindle K to permit of this movement.

A few words concerning the complete machine employed in these operations may now perhaps be usefully given. The general arrangement of it just ready to commence thrust boring is also shown in the drawing on page 522, which gives, in addition to the pilot head and its control mechanism—just described—sections showing the pipe passing under the narrower and wider stretches of the canal.

In these drawings A is the actual thrust borer; B is a 10 horse-power four-cylinder petrol engine; C is a high-pressure hydraulic pump, having a working pressure of 1½ tons per square inch; D is a water supply tank for the pump; E is a flexible pressure pipe from the pump to the borer; F is a flexible return pipe from the borer to the water tank; G_1 and G_2 are piston-rods, each having a fixed hydraulic piston in the middle of its length; H is a crosshead capable of moving along the piston-rods G_1 and G_2, and is comprised of two hydraulic cylinders, mounted on the piston-rods, which are rigidly built together by a heavy steel frame; I is a control valve, which governs the movement of the crosshead H. The pump at ground level is kept running continually while the control valve stops, or moves the crosshead in either direction. The crosshead is capable of a 60-ton push or pull when working at maximum pressure. We believe that the maximum pressure which had to be applied during the Greenford operations was 28 tons. J_1, J_2, J_3 and J_4 are small valves which permit of the return or non-working stroke of the crosshead to be made at double speed. K is the boring pilot, which is shown to an enlarged scale at the left-hand bottom corner of the drawing.

The actual lengths of the two bore-holes near Greenford are 60ft. 6in. and 86ft. respectively, and the gradients at which they were laid were 1 in 105·5 in the first case and 1 in 37·33 in the second. We understand that the controlling apparatus worked most effectively, the specified gradients being rigidly adhered to and accurately maintained from end to end of the holes. Usually, we gather, readings of the level of the water in the gauge pipe were taken for each boring rod length, *i.e.*, 6ft. or two strokes of the machine. The work was carried out under unusually severe weather conditions in January and part of February of this year. In each case the thrust boring was made on the up gradient, the sizes of the pilot head in each case being 6in. The pipes used were standard cast iron, 9in. internal diameter, spigot and socket turned and bored pipes, the diameter over the sockets being 14in. The diameter of the enlarging head employed was 17in. The sewer trench on the higher, or north, side of the canal in the case of both lines of pipe was continued to within 10ft. of the water's edge, and the boring pits, which measured about 8ft. 3in. by 4ft. 3in. between timbers, by 15ft. deep, were sunk well away from the south bank of the canal. Apart from digging the pits and fixing the machine, the time occupied in making the shorter pilot boring was eight hours, or at the rate of 8 min. per foot run. The longer pilot boring occupied twelve hours, or at the rate of 8½ min. per foot run. The pipes were in 12ft. lengths and each weighed 7 cwt. It took some two to three hours to get each pipe into position and the joint made, and on the average the time taken to enlarge the bore hole and pull in one length of pipe was 30 min. Some idea of the saving of time and money by carrying out the working by thrust boring instead of by damming and excavation or by tunnelling can therefore be obtained from these figures by those accustomed to operations of this kind, though it should also be remembered that the entire stoppage of the canal would have necessitated the payment of an indemnity which would itself have run into many hundreds of pounds.

We may here say that the inventors state that the same machine which made the 17in. holes for the work at Greenford would make holes 24in. in diameter, and that is what they consider the maximum size to which thrust boring could be applied, and the ordinary unit length of boring would be some 100ft. It is not their idea to confine the use of the machine to such special work as is described in the foregoing, but to apply it also to ordinary long-distance sewer work, in which, they point out, a considerable saving could be effected as compared with deep trenching, taken in conjunction with road reinstatement. We may say that the depth at which the Greenford borings were made was about 12ft. 6in.

The sole licencee for the United Kingdom for the Mangnall-Irving thrust borer is the Hydraulic Engineering Company, Ltd., of Chester.

SIXTY YEARS AGO.

THE circumstances which led up to a stoppage of work at the Gorton Foundry of Beyer, Peacock and Company sixty years ago are of some interest at the present moment, as an illustration of the growth of trade unionism and the manner in which the unions or "clubs," as they were then commonly called, began to seize power. On March 5th, 1866, Beyer, Peacock started an assistant foreman in their smithery and forge. The new man, Samuel Hall, had for many years been foreman at the London and North-Western Locomotive Works at Longsight, and brought a twenty years' record of good character with him. Nevertheless on his appearance in the shops some two hundred smiths and strikers ceased work and walked out in a body. Their reason was later in the day conveyed to the management in a letter which we reproduced in our issue of May 4th, 1866. They had, they said, unanimously resolved not to work under Hall, alleging that he was a man of no experience and would not give satisfaction, either to the firm or themselves. They added that at Longsight he had "changed more hands than any other firm." As time passed the absence of smith work began to affect the other departments, and in order to avoid the discharge of the remaining hands—some 1500 or so—it was decided to engage new smiths. Under police protection new men were taken on until on March 31st a deputation, consisting of two representatives of the Amalgamated Society of Engineers and one of the smiths on strike waited upon the firm "for the purpose of trying to bring about a settlement of the dispute." The deputation admitted that employers of labour had a perfect right to engage whom they thought proper as foremen, that the firm's men had done wrong in leaving their work, and that the "club" did not approve of their action. It was also admitted that the new hands could not be dismissed, and it was agreed that the strikers should be taken back to the extent of the vacancies available. Precise terms as to which men were to return were amicably settled at later conferences, and a list of 113 names was drawn up. Two days before the restart, however, the strikers executed a complete *volte face* and declined to return unless Hall was dismissed and unless they were all reinstated as a body. On investigation the firm found that the change in spirit had been produced by the activities among the men of the head secretary from London of the Society to which they belonged, the Amalgamated Society of Engineers, Machinists, Millwrights, Smiths and Patternmakers. The firm replied that unless the strikers resumed work as arranged their places would be filled. The club responded that unless the men were taken back as a body—Hall in the meantime had resigned—all the remaining club men in the firm's employ would be instructed to cease work. The firm called a meeting of its men who in all things agreed with its views, but insisted upon obeying their union's orders. It was decided that "the firm was not justified in opposing single-handed the action of the Amalgamated Society," and that there was no alternative but to close the works. A week's notice to all the hands was therefore given, and on April 21st "the largest locomotive engineering works in this country" were closed.

DEVELOPMENT of an additional 22,000 horse-power on the Nepisiguit River, New Brunswick, will cost the Nepisiguit Power Company, Ltd., a subsidiary of the Bathurst Company, Ltd., 18 dollars per horse-power.

Fuel Research: The Report on the Coal Industry.

By PROFESSOR HENRY E. ARMSTRONG.

THE serious competition with the Germans we had to face, especially in the dyestuff and iron and steel industries, had brought the value of scientific inquiry home to our public even before the war. During the war full proof was given that scientifically trained workers were not only behind the Army but indispensable to industry in all its branches. We further made the discovery that, when properly led, our scientific workers were at least equal to those of any other nation. A coincident, correlative discovery, not equally emphasised, was that the commercial class not only cannot any longer run alone but is incapable of taking sole command: it still arrogantly attempts to do so but is everywhere failing in consequence. We have yet to recognise that the administrative, political class is in a still worse quandary: that the factors entering into our affairs are so numerous that no one type of mind can grasp them. Had we realised this, the Coal Commission would have been so chosen that it could have dealt with the broad problems of the industry in their entirety. They have been so partially considered that the solution offered touches the issues only at their fringe. Constructive proposals cannot well be developed without scientific study of the industry in all its applications.

The report contains a section on "Research." This cannot be the work of the Royal Commissioners and we can only guess that it was inspired by the Fuel Research Board. This has always been a mysterious body. We doubt if it had ever had any corporate existence. It is said that no meetings were held during the first two years of its nominal existence, and that its appointed technical adviser was never consulted. Far from helping, the one chief effect of "The Board" has been to warn off, as far as possible, all other workers from the field: to maintain a "close time" against research in the most important of all our industries.

In no other field of activity has the Department of Scientific and Industrial Research subsidised such a Board. The research institutes working under its ægis are all on a 50/50 per cent. basis, each acting in conjunction with its specific industry, the industry organising the work of inquiry and shouldering the entire burden of the work, the Department but giving money and supervising—nothing more than accounts. The inability of the Department to supervise the work of scientific workers is, in fact, most clearly shown in the failure of the Fuel Research Board. A competent Department would have seen to it that the programme of work drawn up was practical in character. Sir George Beilby was supposed to have undertaken to produce oil for the Navy, as an incidental to the production of a smokeless solid fuel. The late Admiral Fisher was quite hurt when, in my lively correspondence with him in *The Times*, I ventured to suggest that his friend was not likely to satisfy his demands. Nothing was ever done to justify the undertaking. No one with experience of the subject was consulted; no one engaged outside in the work could obtain help from the Board. All that was done and done at great expense, at Greenwich, was to make sponge-cakes out of coal, by baking it in a closed chamber in small tins, the coal, the cake and the products given off as steam being separately weighed. The information gained was of no practical value and could easily have been obtained at small cost by experiments at the bench in existing laboratories.

The Fuel Research Board, in fact, has nothing useful to show for the half-million or so it has thoughtlessly expended—thoughtlessly in the sense that the outlook has never been scientific and practical. Had it been properly constituted and efficient, it would have laid bare the unscientific condition of the industry, it would have made the needs and possibilities known and done much to promote the desirable changes and developments. The present strike would have been impossible. During and since the war the Germans have fully developed their brown coal industry, including that of by-product recovery, so that they are fast becoming independent of hard coal. This they have done by giving man of affairs, engineer and chemist co-ordinate rank and responsibility in the management.

In so far as research work has helped industry, it has done so whenever it has been interlocked with an industry; it has never operated from outside to help in any essential way. The Germans have succeeded by internally organising all their works' operations upon scientific lines. The phenomenal success of Scottish Dyes, Ltd., has been the outcome of such a policy. The founder, Mr. Morton, is an idealist with an admiration for and belief in the scientific spirit but himself in no way informed on the purely technical side. The scientific spirit has never been demonstrably behind the Fuel Research Board.

What those of us who seriously consider the problems of coal hope for is that the attempt to centralise and nationalise coal inquiry will be forthwith abandoned. The history of scientific inquiry and invention is one continuous argument against centralisation. The wind of discovery bloweth where it listeth, rarely according to forecast. Team work is much talked of to-day but it is of no value unless properly led. Few of the institutes that have been established are more than marking time: the workers are not led and their work is in large measure academic and of minor practical value. Leaders gifted with the originality, breadth of outlook and introspective power that are needed for industrial research are rarely to be found.

Not only is fuel research a failure but mine research has also led to little of real value. A Safety of Mines Research Board was established a good many years ago, chiefly to study the manner in which mine explosions are propagated through a mixture of coal dust and air. The mine owners themselves had carried out large-scale experiments previously at their own cost. The Government work on this and other mine inquiries has involved an annual outlay by the State of about £50,000. Little advance has been made and the work done has been mainly of an academic character. Most progress has been made in the study of diseases specific to miners. It is obvious that the organisation lacks the necessary leadership and originality of outlook.

All future research work must be directly coupled with the industry in order that, with as little delay as possible, this may be infused with the scientific spirit. This, indeed, is our first need. Being the foundation stone of all other industries, it is essential that the coal industry, before all others, be placed upon a scientific footing.

Whatever Board be constituted, it must have in its service all the best available people and be divided into at least two sections—the one mainly mechanical, dealing with coal-mining problems; the other mainly chemical, dealing with the preparation and utilisation of coal. Such a Board could administer funds with some understanding and discretion. It should be deliberative and advisory but not itself undertake research. Apart from large-scale work undertaken at the collieries, academic workers, whose name is now legion, would only too readily engage in properly defined inquiries. That such is the case is obvious when the remarkable work is considered which has been carried out during a long period first at Leeds and now at the Imperial College, London, by Professor Bone. At least, the problems of gaseous fuels are being laid bare and solved by these researches. The nature of the coal substance itself is being well explored at the same school. These are but illustrations of what can be done from the university side. On the practical side, the South Metropolitan Gas Company, having at last been moved to treat the subject of the low-temperature carbonisation of coal seriously, has recently made known what is admitted to be the most important contribution we have yet had to the study of the problem of coal carbonisation. In the main, what we need is industrial experiment, not academic inquiry, into matters of no particular moment.

Reference is made in the report of the Commission to work on the "liquefaction of coal" by the Bergius process and it is rumoured that the Fuel Board has paid a large sum for information. Surely it should have been realised that all is not gold that is German and that such action is undesirable. Scientific proof that the main coal substance can be "liquefied" by hydrogen is wanting; the theoretical probability is slight. Quite recently, the Mülheim (Ruhr) Coal Research Institute has expressed an unfavourable opinion of the process, finding that such oil as is formed is only suitable as fuel oil.

In a previous article—see THE ENGINEER, April 2nd, page 375—I have complained of the ignorant way in which we have hitherto treated coal. Far worse is our ignorant treatment of knowledge and experience. The Fuel Research Board has never taken notice of outside special knowledge and, having little within, has failed to deliver goods. A really useful termination of the Board would be to hand over the station to the neighbouring gas company, which may be trusted to make good use of the site and appliances. If it were declared "out," we might see our way to useful work. To carry into effect recommendations for further research on bureaucratic lines such as are advanced in the Commissioners' report will be to sacrifice a supreme opportunity.

It is being made clear to many of us that during the past dozen years the independent foundations of our scientific society have been insidiously undermined: in fact, that the future of scientific research may be in grave danger, and needs to be guarded against further bureaucratic attack. We may take warning from the effect produced by the Board of Education in enforcing a system of study and of examinations upon the schools, which is admittedly leading to intellectual sterility and loss of individuality.

When Parliament decided that a large sum should be devoted to the work of scientific inquiry, no one contemplated the establishment of a new Government Department which should itself expend a major share of the grant, thus depriving research workers, in general, the universities in particular, of the financial aid they so greatly need. The Royal Society, which should be the guardian of the interests of all original workers, has allowed itself to be thereby pushed into the background and the functions it formerly exercised so well to be abrogated. The recovery of our scientific liberties should be undertaken without delay. No Government Department is necessary.

The Status of Naval Engineers.

(Contributed.)

IN view of the discussion on the Fleet Order of last November and its effects on the status of Engineer Officers of the Royal Navy, it is perhaps of more than historical interest to recall the conditions which ruled in the German naval service relevant to this subject, both before and during the war, and to notice the sequel, whether it were accidental or otherwise. The present writer had somewhat exceptional opportunities of studying these conditions during a long residence in pre-war Germany and close observation of naval developments there.

It may be said at once that the general status of the German naval engineer officer in 1914 was inferior to that which his British colleague occupied even before the Selborne-Fisher scheme of 1904. By his brother officers of the executive branch he was treated on all occasions as a social inferior, the wide gulf between the two branches being instantly perceptible to the most casual onlooker. Yet the German engineer officers, if few of them bore the ennobling prefix "von," were in the main a fine body of men, highly educated, devoted to their work, and by no means devoid of social polish. Nevertheless, it was easy to see that they accepted as a matter of course the patronising and supercilious attitude of the executives, an attitude no less manifest in professional than in social intercourse.

Now for the sequel. While the tactics pursued by the German navy during the war were not such as to impose any severe strain on the machinery of vessels comprising the High Sea Fleet, which put to sea only on the rarest occasions, engine-room troubles appear to have occurred with such frequency as to embarrass the plans of the High Command. The principal witness is the late Admiral Hugo von Pohl, Chief of the Admiralty Staff until February, 1915, and from that date to the following January Commander-in-Chief in the North Sea. In his letters and private diary, extracts from which were published after the war—"Aus Aufzeichnungen und Briefen während der Kriegszeit"—he records an extraordinary chapter of accidents which the fleet suffered during his tenure of command. Writing on March 10th, 1915, he said: "During the next few days it will not be possible to go out, because some of the ships must be docked for overhaul. This—the fleet—is a queer sort of family. There is always something wrong, now with one and now with the other of them. One may consider oneself lucky when one has got all of them together." On July 17th he wrote:—

"I wanted to make a sortie to-day, in order at last to get the ships moving again and perhaps come within reach of the enemy: now four ships all at once have failed, owing to engine defects. Among them is my own ship, the battleship Friedrich der Grosse. The fact that there should always be so many ships in need of repair and that I should thereby be hampered in my actions is enough to drive one to despair."

On July 19th, he records, the fleet contrived to get to sea, and steamed as far as the Eider lightship. Here, however, a number of ships developed engine troubles and it became necessary to return. On July 20th he writes that he does not expect to be able to move again for nine days, owing to these and other repairs. On August 17th, his diary shows, three out of eight destroyers which had been sent on a special scouting mission to Horn's Riff were compelled to turn back owing to machinery defects. On several other occasions the operations of the fleet were handicapped by the same cause. There is, further, abundant evidence to show that the steaming performance of German warships did not come up to expectations. At the Battle of Jutland, as Commander Georg von Hase, gunnery officer of the Derfflinger, testifies in his book, "Die Zwei Weissen Völker," the designed speed of the German battle-cruisers proved illusory. In Chapter VII. he states:—"At 7.21 p.m. the Commander-in-Chief made the signal, 'Battle-cruisers to pursue.' But our squadron could not maintain more than 25 knots for any length of time, while the British were romping away from us at 28 knots . . . The fact was that by completely outflanking us in spite of our utmost speed, Admiral Beatty executed a brilliant manœuvre, and his ships a magnificent engineering achievement."

Hardly anywhere in the German war histories does one find a word of praise for the engineering branch, but whether this omission is intentional—all the naval historians being executive officers—or is due to the absence of any special cause for approbation in this respect, must be left to surmise. The question as to whether the derogatory treatment meted out to the engineer officers of the German navy had anything to do with the mediocre average of engineering efficiency maintained by that navy all through the war must also be left open, but it is inevitable that certain conclusions should be drawn from the data available.

AN expedition which is being sent out to Greenland by the University of Michigan is to establish meteorological stations, which, it is hoped, will be able to forewarn Eastern America and Europe of coming wind storms.

Railway Matters.

A NEW type of ticket-issuing machine is shortly to appear on the Underground Railways, which will fully print, number and date the ticket at the time of issue at the rate of five per second.

IN the "Personal" advertisement columns of *The Times* of the 29th ult. was an advertisement stating that a few large shareholders in British railway companies wished to get into touch with other large shareholders to discuss questions of practical economy.

AT a dinner of the Manchester Cotton Association on the 30th ult., Mr. Amery said that the Cabinet had authorised him to introduce, during the next few weeks, a measure for guaranteeing £10,000,000 for a progressive railway policy in East Africa. He did not suggest that that was enough; he believed that much more would be wanted in the future.

THE Legislature of Manitoba has passed a Bill authorising the construction of a railway line from a point near The Pas on the Hudson Bay Line to the Flin Flon Copper Mine in Northern Manitoba. Construction will not be started until assurance is given of the intention of the Harry Payne Whitney interests, of New York, to construct a mining plant and smelter.

A SIGNIFICANT inquiry was recently addressed to Sir Ralph Wedgwood at the Railway Rates Tribunal by Mr. Jepson, a member of the Tribunal. He asked whether it was not the fact that the original reason for workmen's tickets being cheaper than third-class season tickets no longer held. Mr. Jepson suggested that nowadays workmen's wages, in general, were higher rather than lower than the salaries of clerks, typists and others who used third-class seasons. Sir Ralph agreed.

IN view of the complaints made by railway companies as to their losing valuable traffic because of its being sent by road instead, the following remarks by Mr. Roger Gibb, of the Great Western Railway, to the Railway Students' Association on April 22nd are instructive:—"Estimates made by one railway company tend to show that that company had lost to road competitors about 5 per cent. of their gross competitive goods revenue, representing rather less than 2 per cent. of their total gross goods revenue."

IT is gratifying to find that the improvement in the receipts of the four grouped companies that set in with the beginning of the year continues. For the first fifteen weeks of the present year the results, when compared with those of the corresponding period of last year, show increases as follows:—London, Midland and Scottish, £77,000; London and North-Eastern, £366,000; Great Western, £241,000; Southern, £119,000. The extent of the increase on the London and North-Eastern is not only very satisfactory, but significant.

THAT the London, Midland and Scottish Company does not intend to relinquish its hold, exercised by both the former London and North-Western and Midland sections, on Swansea is indicated by the announcement that the coal tipping plant and the approaches thereto at King's Dock, Swansea, are to be improved in order to deal with 20-ton wagons. That step has, of course, been brought about by the greater use now made in South Wales of 20-ton wagons owing to the rebate given, when such trucks are used, by the Great Western Railway.

THE railway statistics for January last, compiled by the Ministry of Transport, have recently been issued as a Stationery Office publication, price 3s. They show an increase, by comparison with January, 1925, of 0·4 per cent. in the number of passenger journeys, but a decrease of 1·9 per cent. in the receipts from passengers and of all passenger traffic, except mails, of 1·7 per cent. There was a decrease of 0·3 per cent. in the passenger train mileage. Goods traffic decreased by 3·7 per cent., goods receipts by 2·5 per cent., and goods train mileage by 2·9 per cent. As the average length of haul was greater the ton-miles fell by only 0·7 per cent.

THE Japanese railway authorities are, it is said, contemplating the erection of an up-to-date railway station at Osaka, which is to be a building of steel construction. It is understood that the general plan will provide for an elevated track with the necessary accommodation for the travelling public—*e.g.*, waiting rooms, &c. &c.—on the ground level. The total area covered by the new station will be about 1000 tsubo—nearly 4000 square yards—and the total cost is estimated at between three and four million yen. The work will be spread over a number of years and will not, it is thought, be completed before 1931 or possibly later. The scheme, it is believed, will also include the construction of an hotel and provision for modern baggage transporting appliances, elevators, &c.

IN article No. IV. of the series "Notes on British Railways by a Continental Engineer," which appeared in our issue of February 26th, mention was made as follows of the three-link coupling on the British wagon: "When, in consequence of the war, British wagons first made their appearance on the Continent, they were first of all regarded as being clumsy and out of date. But after they had been in use for some little time, many of the French shunters formed a high opinion of the simple link couplings which could be attached and detached from the side of the wagon, whereas with the screw coupling the shunter is obliged to get in between the vehicles. The link coupling is one of the reasons why shunting is so quickly done in England." The means employed that allows for the shunter to stand outside the wagons when coupling and uncoupling is a coupling pole which was invented about 1880 and adopted by all the companies in 1886. Most of the men are great adepts with the pole, and in an official test at Derby many years ago a man coupled and uncoupled twenty wagons in 75 sec., or one for every 3.75 sec. The former Furness Railway took a great interest in such trials and gave prizes. That practice is kept up by the present Furness and West Cumberland District of the London, Midland and Scottish Railway. On Christmas Day last at Carnforth a man coupled and uncoupled sixteen wagons in 66 sec., or one for every 4.12 sec., and at Barrow, on Good Friday, a man did twelve wagons in 47 sec., or one in every 3.92 sec.

Notes and Memoranda.

A DRAGLINE excavator having a total weight of some 500 tons is said to have been produced in the United States. It is supported by four caterpillar belts, 36in. wide, which distribute the weight to such an extent that the machine can be operated over soft, yielding ground without difficulty.

WHAT is believed to be a record in colliery engineering has recently been set up by the Cannock and Rugeley Colliery Company's staff of engineers, and is briefly recorded in the *Iron and Coal Trades Review*. Commencing on Thursday afternoon after completion of the winding shift, the engineering staff dismantled an old winding engine, which had been in use for nearly forty-two years and which was built by R. J. and E. Coupe, of Wigan, and installed a new one in five and a-half days. The new engines were erected on the existing foundations, which, however, required considerable alterations and additions, and steam was turned into them on the following Tuesday night. The new winding engines, which weigh approximately 75 tons, were built by the Worsley Meanes Ironworks, Ltd., successors to Messrs. Coupe.

APPARENTLY the Staten Island highway, used extensively for the night delivery of farm products into New York, can claim to be the best lighted rural highway in the United States. The Hyland boulevard, which runs across the island, is of concrete and 50ft. wide, with 10ft. sidewalks on each side. General Electric Novealux highway units, consisting of nested parabolic reflectors and equipped with 250 candle-power lamps, are used. The first installation included 119 units, but 400 have since been installed on the island. The lights are mounted 32ft. 6in. above the road surface. On the Hyland boulevard there are 166 lumens per running foot of road, an increase of 100 per cent. over the original installation. It is believed that there is no other rural highway in the United States with so high an illumination.

IN the course of a paper on "The Use of Breathing Apparatus in Mines," submitted at a meeting of the Associate and Students' Section of the North of England Institute of Mining and Mechanical Engineers, Mr. Francis J. Johnston questioned whether in the case of explosions a fully-equipped rescue team would not be better employed in erecting barriers so that when a irrespirable zone was removed any men who might be in-bye could walk out without the aid of apparatus of any kind. The transport of a container of liquid air—which was equivalent to 750 cubic feet of oxygenated air—to a number of men so trapped might be a useful temporary expedient to keep the air fresh where the men were found. By pouring out a small quantity of liquid, a volume of oxygenated gas 800 times greater in volume was instantly produced, which would help to prevent accidents should the emergency arise.

SOME interesting experiments with icebergs will, according to the *Canadian Engineer*, be conducted this summer by Dr. Howard F. Barnes, of McGill University, at Twillingate, Newfoundland. Dr. Barnes has already demonstrated the value of thermit as a medium for disintegrating ice, and he will employ that method this summer. His original intention was to go to Greenland for the purpose of studying the source of icebergs and of applying heat treatment to see how icebergs reacted, but, as he is unable to go to Greenland, he will operate off the coast of Newfoundland instead. In a statement to our contemporary, Dr. Barnes says that he will employ charges of thermit varying in weight from a few hundred pounds to half a ton put in place on the iceberg, and by that means set up a line of temperature reaction which will cause the radiating energy to be thrown into the ice in such a form that it will penetrate to a great distance before it is entirely absorbed. In that way the heat wave will loosen the binding force between the granules, will set up a disruption in the ice molecules, and will cause a point of instability and strain, owing to the high coefficient of expansion of the ice at or near the freezing point. Dr. Barnes states that he has discovered that the most active agent for cracking and disintegrating icebergs is the change of temperature caused by the variation from day to night and night to day, which sets up an unequal strain on the ice and causes the cracking. The idea in the experiments is to set up this strain artificially, and judging from his past experience Dr. Barnes has every reason to believe that he will be successful.

A GRAPHIC description of the accident which recently happened to one of the blast-furnaces of the Woodward Iron Company of America appeared in the *Iron Age*, and from this account it may be gathered that the furnace in question was completing a very satisfactory campaign, during which it had produced quite a record tonnage. The last four days of the campaign resulted in the production of an excessive proportion of high sulphur foundry iron, and for this reason the furnace was ordered to be blown out; this operation had proceeded in the usual manner, and without notable incident, until the following morning, when the furnace slipped, according to the statement of those close to but not immediately around the furnace. Directly following the slip, the furnace shell was completely blown off, at a point two sheets above the mantle. While it would have been easier for the shell to have fallen forward into the casting house, or to the free side opposite the dust catcher, it chose the more difficult one of going toward the skipway, which was buckled and bent backward at a point somewhere below the centre of the incline. The top of the furnace found a resting place upon the stock bins. That the furnace was projected upward is indicated by the undisturbed gas and blast mains, which paralleled the stock house under the skipway. The higher of these mains is situated at an elevation of about 10ft. above the mantle, notwithstanding which it shows no mark of impact. With the upper part of the shell removed, the remaining stock in the furnace was blown out by the entering blast and quickly deposited around the furnace, principally within a radius of about 75ft. of the furnace base. The recording gas pressure gauge attached to the gas washer, which is connected with a gas main leading to No. 2 furnace, showed that during the night several slips occurred previous to the final one which coincided with the destruction of the furnace.

Miscellanea.

IT is reported from Lisbon that the Government has been authorised definitely to ratify the provisional contract with the Italian company, Italcablo, for the laying of cables between the Azores and Cape Verde, between Italy and the Azores and between Lisbon and Malaga.

WITH a view of making use in its own plant of ochre deposits from which the pigment has hitherto been exported to the United States, the Romaine River Oxide Company will shortly establish at Levis, Que., a large paint manufacturing plant. The outlay, it is said, will be over a million dollars.

THE International Laundry and Allied Trades Exhibition, which was due to be held at the Royal Agricultural Hall, Islington, London, N. 1, from May 10th to 18th inclusive, has been postponed to May 21st to 28th inclusive, owing to the recent state of national emergency, and will remain open the whole of Whit Monday. The Exhibition will be open from 11 a.m. to 9 p.m.

THIN sheet celluloid is, according to *English Mechanics*, now extensively used in America as a substitute for tracing cloth, and is found to be especially useful for record data, maps or diagrams which are subject to frequent revision and much handling. The celluloid employed for this purpose is about ·015in. thick, and has a matt surface on one side. The material is not rolled, but is kept flat and may be stored in cabinets without putting separators between the sheets.

IF the scheme now under consideration by the Bath City Council goes through, the old bridge which spans the river Avon at the bottom of Southgate-street, will, says the *Builder*, disappear. The bridge, which consists of five arches, was built in 1362, and had at one time a chapel upon it. In 1754 it was widened and footways provided for the first time. The great increase in traffic is the reason given for the proposal to demolish the bridge, which will be replaced by a wider structure.

THE period in which flying machines entered for the Air Ministry's helicopter competition were required to pass the prescribed tests ended on April 30th and the competition is now closed. Applications to enter machines were, we are officially informed, received from thirty-four competitors, but only one competitor actually sent a machine to Farnborough, where the tests were to be carried out. This machine did not, however, carry out any of the tests, and none of the prizes offered has been won. It has been decided not to renew the competition.

A REPORT from Berlin dated May 8th states that the Rhenish Westphalian Steel Trust came officially into existence on that day. The extraordinary assembly, at Essen, of the new Trust, which is known as the Vereinigte Stahlwerke Atkiengesellschaft, formerly took over the works of the various concerns forming the new trust, viz., the Phœnix, Rheinstahl, Gelsenkirchen, Bochumverein, Deutschluxemburg, Vanderzypenwiissen and Thyssen. The managing director of the new trust will be Dr. Voegler and its capital will be 800 million marks.

PRODUCTION of slab zinc at zinc reduction plants in the United States in the year 1925 amounted to 611,645 short tons, valued at 92,970,000 dollars, according to statistics compiled by the Bureau of Mines, Department of Commerce. This compares with the 1924 production of 552,825 short tons, valued at 71,867,000 dollars. Of the 1925 output, 572,946 tons was primary production, 555,631 tons being from domestic ores and 17,315 tons from ores originating in Canada and Mexico. Re-distilled secondary production amounted to 38,699 tons.

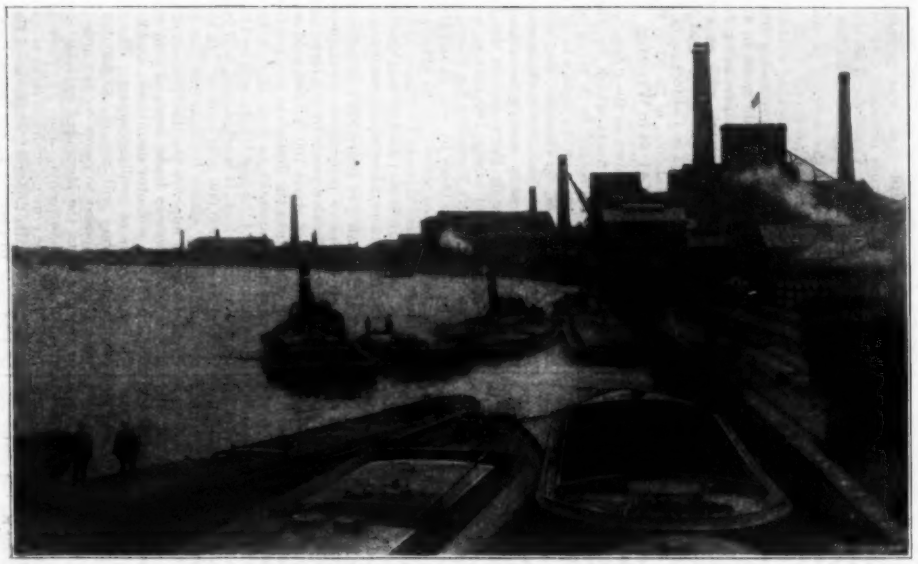
IN comparison with the average production in other oilfields of the world, Alberta oil wells now producing show a high average. The Royalite well south of Calgary in the Turner Valley field is producing 400 barrels a day of almost pure naphtha, while wells in the Wainwright field, east of Edmonton, are producing from 80 to 100 barrels a day. This compares with an average of 6·59 barrels from 298,915 wells in the United States in 1924, with an average of 55·53 in California, of 20·9 in Texas, of 8·32 barrels in Oklahoma, of 20·63 in Montana Rocky Mountain area, and of 41·84 in Wyoming.

THE curious glider known as the "Sea-flea," on account of the two projecting floats which by their movement cause the vessel to proceed by a series of hops, is now undergoing the first test on the open water. Designed by a Russian engineer, M. de Gasenko, and fitted with a 180 horse-power motor, which drives the aerial propeller, the "sea-flea" has already undergone numerous successful trials on the Etang de Berre and in the Estaque roads, attaining a speed of nearly 100 kiloms. an hour. M. de Gasenko has now left Marseilles for Barcelona, whence he hopes to proceed to Oran by way of the Balearic Islands, a distance of 520 sea miles. If his attempt be successful, the inventor then intends to travel along the African coast to Casablanca and Dakar, and thence on to South Africa. His crew consists of one mechanic.

THE Municipality of Budapest has before it the carrying out of an extensive programme of improvements which will take some twelve years to complete, and will require an expenditure of about 100,000,000 gold crowns. Among the proposed works the first place is taken by the construction of a new gasworks to cost 20,000,000 gold crowns. The production of the new works is to be 148,000,000 cubic metres a year, which, it is estimated, will yield an increase in receipts of 2,000,000 gold crowns. In the second place the Municipality means to modernise and develop its electrical works, to improve the distribution of water, to construct new tramway lines, especially in the suburbs, to acquire fifty new motor omnibuses, and to push forward the construction of dwelling-houses. The first part of the programme alone will require 88,400,000 gold crowns, which it is proposed to cover by the anticipated increase in receipts from the Municipal exploitations, by savings effected in investments, and by part of a loan of 100,000,000 gold crowns, which is to be raised. It is hoped so to improve the financial situation of the town that it will be able to proceed to the realisation of the second part of the programme, which includes the construction of baths in Budapest, different public buildings, eighteen school buildings, a hall for the Fair and roads, in ten years.

THE LUBRICATING OIL DEPOT AT WANDSWORTH OF THE VACUUM OIL COMPANY, LTD.

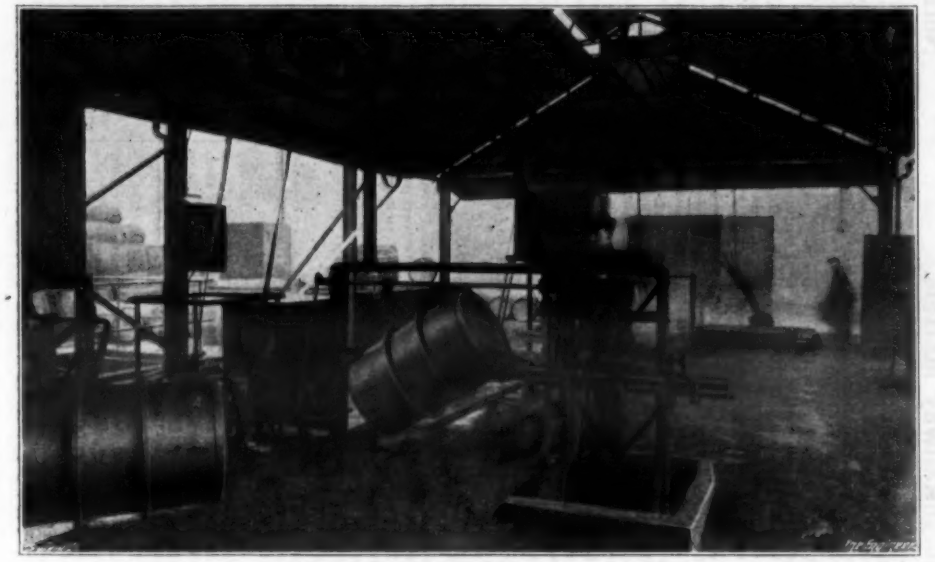
(*For description see page* 531)



VIEW OF QUAY SHOWING TANKS AND BARGES

THE LABORATORY

POWER STATION



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"The Engineer" and the Strike.

On May 7th, for the first time since its establishment over seventy years ago, THE ENGINEER *failed to appear. Nor could it be published last week. We do not offer an apology for an occurrence which was, as all know, wholly beyond our control. But a few words of explanation seem to be needed. Some of our readers have expressed surprise that the Technical Press should have suffered the same fate as the Political Press. We share that surprise. Stopping the Technical Press was from every point of view a mistake on the part of the leaders of the General Strike. Some selection was made in the attack upon other industries, and it might well have been made in the case of scientific and technical newspapers. But it was not made, and our printers were called out with all the other printers in the country. We have given very earnest consideration to the best course to pursue in these circumstances, and have decided that nothing could be gained by bringing out the two missing issues so long after their proper dates. To-day's number, therefore, follows consecutively upon that of April 30th, but advertisers have been notified that special arrangements have been made to fulfil our contracts with them.*

THE ENGINEER.

MAY 21, 1926.

The General Strike.

THE Great Strike ended at midday on Wednesday last, May 12th. From the beginning it was a gross mistake and in the end a total failure. The Trades Union Council did not succeed in holding up the essential services of the nation, and its efforts to coerce the Government were stultified by the repeated assertions of the Prime Minister that nothing short of an unconditional withdrawal of the strike notices would for one moment be considered by the Government. In the face of such determination any effort to force Parliament to do ought which it held it wrong to do was doomed to failure. But the Cabinet—and, let us say in all fairness to the other Parties in the House of Commons, that they, too, recognised the inquity of a General Strike—was far, very far, from being isolated in its determination to defeat the efforts of the Trades Union Council to coerce the nation. From every side volunteers in increasing numbers offered their services in the crisis, and before two days were over the feeding and transportation of the people was made secure. Important as the unwavering attitude of the Government was, it must be said, with all pride, that it was the behaviour of the public as a whole that brought the Great Strike to nought. The country has, indeed, gained from the struggle a new confidence in itself. It is now abundantly evident that whoever dares to foment an insurrection against constituted authority in this country must be prepared to face, not only Parliament and the forces it can command, but the public will as a whole. We know now that the British nation is at heart profoundly constitutional and that no effort, however great it may be, will ever prevail against its rigid determination to prevent any attempt to overthrow the familiar and popular form of Government, and replace it by a method in which a threatening minority overrides the policy of the elected House. From this fact we may derive some satisfaction. The trades unionists have learnt a lesson they are not likely soon to forget; but, greater even than that, the nation as a whole has been awakened to a knowledge of its great power. With this General Strike behind us we could look forward to another outbreak with equanimity. The value of the General Strike as a political weapon in Great Britain has been discovered. Its weakness has been revealed, and we may say with no little confidence that it is not likely to be called in aid for many years to come.

The protagonists of the strike endeavoured over and over again to persuade the public that it was an industrial dispute. No one was deceived thereby. The only great industrial dispute was, and still is, that between the mineowners and the miners. The railways and transport systems, the Press, the power-houses, the brewers and the flour millers, and so on, were not, at the moment, engaged in any discussion with their people. Yet they were called out. Not in sympathy with the miners, for they came out, such of them as obeyed, at a moment's notice by the orders of the T.U.C. Those orders were transmitted through their own unions, but customary terms of notice were not given, and in every case contracts were broken and the strikes were "illegal," as Sir John Simon pointed out. There can be no question whatever that the strike was instituted with the intention of intimidating the Government; it was not an industrial strike, but a strike with a revolutionary atmosphere. And let us say here, in justice to those who organised the outbreak and in praise of the British character, that at no moment was there any serious apprehension of a real insurrection. On their side the unions aver that they issued orders that violence and rioting should be avoided. We believe that they actually did so, and we believe further that the few disgraceful episodes which have been put on record were the acts of irresponsible hooliganism and not of organised forces. But the position was necessarily perilous, and had it not been for the imperturable temper of the British people such a fire might have been lighted by some spark struck in a moment of bad temper as would have set the whole country ablaze. It has been frequently said by foreign revolutionists who despair of this country that in such a phlegmatic land a revolution is impossible. The events of the past nine days dispose us to believe them. There was not only a very small display of hot tempers, but there was a very marked good humour on the part of the public, which in some respects seemed rather inclined to make fun of the strikers than to take them as seriously as they desired. Who knows but that this feeling had its effect upon the strikers and played its part in the early collapse.

And after it all—what? What single good thing can the T.U.C. claim as the outcome of its efforts? Has the welfare of the country been improved by the check upon its industries? Is the prospect of general prosperity any brighter because supplies have been delayed and deliveries hindered? Can we pay, on an economical basis, higher wages after the loss of the many millions which the strike has involved than before? Are we in a better position to meet foreign competition because for ten days we were unable to meet our foreign obligations? Finally, has the strike effected the settlement of the mining question? The answer to every one of these questions is obvious. The strike has injured us in every way—but one—and it has not brought the economic problem behind the coal dispute the thickness of a thread nearer solution than it was before. On that point let us be absolutely clear. We are forced to admit that in the coal industry there is a deplorable lack of sympathy on both sides. But essentially the problem is an economical

one. It is not in the power of the man with the greatest good will in the world to the miners to settle it by a stroke of the pen. The issue is, purely and simply, the price of coal per ton. That price is now too high. It must be reduced. There are no two views about that. The problem which the adversaries—as we must with regret still call them—have to decide is how to reduce that price, the price of production. Nationalisation could not do it; the appropriation of royalties could not do it; the miners themselves, by becoming owners, could not do it. It can only be done by some such methods as those formulated in the report of the Royal Commission, and if trades unionists, and particularly the T.U.C., will endeavour to procure a calm economical investigation of that problem, an investigation free on both sides from class distinction, they will serve their country—and themselves—ten thousand times better than they did by fomenting and supporting the Great Strike.

We have said that there is one direction in which the country has not been injured by the strike. That way is the sense of security which it has won in the last eventful weeks. For many months and years the fear of revolution has hung over us. Here we had all the elements that in other circumstances, and perchance in other lands, would have provoked a revolution. But they have passed us by. The firm resolution of the British people to be governed by constitutional methods has been made manifest. The bogey has been laid. Revolution is no longer to be feared. Moreover, it is not improbable that after this outbreak we shall know more of industrial peace than at any time for the last twenty years. No one who has studied the times can be in any doubt that disturbing elements have been at work in our midst fostering enmity between employer and employed, between the people and the State. In this struggle they have had their answer; they have played their cards and lost their counters, and it will be long before they can make ready for a new attack. Without them we may, by patience, undo the principles of class hatred which they have ceaselessly inculcated, and with better will between the two great elements of industry we may hope for a quicker return of the long-delayed national prosperity. We have still all those things that go to the making of a great industrial nation. Our workpeople are unequalled in skill and intelligence, our employers are as a whole energetic and progressive, our command of raw materials is admirable; we have excellent systems of transport and an organisation for overseas trade which is by far the greatest in the world. Our one defect has been a failure to appreciate economic conditions. That failure may be attributed in great measure to the promulgation of wrong ideas by false prophets. The prophets have acted and the country has snapped its fingers at them. To tens of thousands of workpeople the real position has been at length revealed. If we can now, by wise and conciliatory councils, persuade them that high output with high wages is the crying need of the country, and if we can, at the same time, by firmness without vindictiveness check the spread of false doctrines, as bright a future as we have ever known awaits us. With the Great Strike over we have discharged from our system much of the poison of twenty years. The crisis is past, and, like a man recently escaped from a great danger, we find new hope, new aspiration, new determination stirring within us.

Light Alloys or Steel?

WHILE, on the one side, engineering developments of to-day call particularly for materials possessing greater strength at high temperatures, there are, in other directions, demands for materials combining great strength, at ordinary temperatures, with a minimum of weight. Such a demand comes mainly from aircraft designers, but it is likely to be made also to an increasing extent in the future in many other branches of structural engineering, more particularly where heavy masses have to be started and stopped at frequent intervals. The reduction of weight in a structure can be achieved in two ways, either by the use of heavy materials having enhanced physical properties, or by employing materials of low specific weight and of fairly good physical properties. Typical of the first type are the high-tensile alloy steels, while the light alloys of aluminium and of magnesium represent the second. Between these two types there is a certain degree of rivalry, and such rivalry frequently leads to the most important advances.

The advantages which can be claimed for each of the two types are fairly clearly defined. On the side of the alloy steels we have the fact that steel of all kinds is a material very familiar to the engineer; while the light alloys are still more or less new to him. Furthermore, the production of steels is in the hands of old-established firms of high repute and the materials thus produced naturally profit from a sense of reliability which it is difficult for newer materials to acquire. The most vital factors, however, relate to the weight-strength ratio and to resistance to corrosion. In regard to the former, the "specific tenacity" of the strongest of the heat-treated alloy steels is decidedly higher than that of the best of the aluminium alloys as yet commercially available, while in resistance to corrosion the best of the rust-resisting steels or alloys of iron-nickel-chromium are undeniably superior to any light alloy. So far, the case would seem to tend overwhelmingly in favour of the alloy steels; and, in fact, a decision in their favour has actually been taken in regard to certain large airships by the Air Ministry. There is, however, a strong case for the defence of the light alloys. In the first place, there is the considerable difficulty of fully utilising the high strength-weight ratio of the steels. Where large and light structures are concerned, weight can only be kept down by the use of exceedingly thin sections. But in the production of thin material of satisfactory quality relatively heavy costs are incurred, to which a corresponding cost in actual construction, owing to the careful handling and accurate jointing which are essential must be added. Finally, there is the difficulty in using and handling a structure built of very thin sections. Another point in favour of the weaker but much lighter material is that it allows of the use of bulkier sections and, from the point of view of rigidity and resistance to flexure in struts and columns, this is an important advantage. These, of course, are essentially questions of design and the difficulty of utilising the high-tensile heavy materials may be readily overcome in some cases and may yet prove insuperable in others. In regard to corrosion, also, the position is rather more favourable to the light alloys than would at first sight appear. The development of processes for the protection of aluminium alloys from corrosion has now been carried so far that practical success can be claimed to a very considerable extent, both by means of electro-plating with zinc or cadmium and by means of "anodic oxidation," which is now widely entering into practice among aircraft constructors. While the invulnerability of the rust-resisting ferrous alloys is not perhaps quite reached, perfectly practicable results can be achieved, provided that the light alloys themselves are suitable and have been rightly treated.

The balance between the two types of material thus rests to a considerable extent—apart from the serious item of cost—upon the strength-weight ratio which is attainable. While it may be that even in heat-treated alloy steels large advances are still possible, there seems to be good reason to think that any early and marked progress in that direction is at least unlikely. With the light alloys, however, the position appears to be different. So far as strength-weight ratio is concerned, the original high-strength light alloy of the "duralumin" type has not as yet been seriously surpassed. Numerous efforts in that direction have been made, but so far none of the claims that have been advanced have materialised into commercial production. But it seems improbable that the very first alloy of a new type to be developed should permanently remain the best that can be achieved. It is not too much to hope, therefore, that in the near future a light alloy considerably superior to duralumin may be produced, whether as the result of work done by the industry itself, or in one or other of the research laboratories which occupy themselves with these alloys. If that can be done, the balance of the case could easily be turned decisively in favour of the light alloy, so that it is a matter which should not be neglected. The whole aluminium industry, the research institutions and laboratories, and the principal users of light structural materials—aircraft constructors primarily—are concerned with the problem. Great progress in aluminium alloys for use as castings has recently been made, largely in this country; it is to be sincerely hoped that efforts to make equally valuable progress in wrought structural materials will not be wanting, and that they will be adequately supported by those concerned with the use of such materials. Safer and lighter aircraft alone is of such immense importance that we cannot afford to neglect any possibility of progress in that direction.

Obituary.

GEORGE PICKLES.

WE record, with regret, the death of Mr. George Pickles, governing director of John Pickles and Son (Engineers), Ltd., of Hebden Bridge, which took place suddenly on May 2nd.

Mr. George Pickles was the son of the late Mr. John Pickles, who founded the firm. He was in his seventy-seventh year, and was, it is believed, the oldest sawmill engineer in the country, having had over sixty years' practical experience in designing all classes of sawmill and woodworking machinery for various purposes.

Report on the Heterogeneity of Steel Ingots.*

AT a meeting of the No. 5 Committee (Metallography, Physics, and Chemistry) of the Iron and Steel Institute held on May 7th, 1924, it was unanimously agreed to request Dr. Hatfield to form a Sub-committee for the purpose of studying the problems of inclusions in steel and of the heterogeneity of steel ingots. The Sub-committee was ultimately constituted as follows:—

Mr. T. P. Colclough (the Park Gates Iron and Steel Company, Ltd.).
Mr. W. J. Dawson (Hadfields, Ltd.).
Mr. J. H. S. Dickenson (Vickers, Ltd.)—*Vice-Chairman*.
Mr. A. P. Hague (Cammell Laird and Co., Ltd.).
Dr. W. H. Hatfield (the Brown-Firth Research Laboratories)—*Chairman*.
Mr. E. F. Law (Sir W. G. Armstrong, Whitworth and Co., Ltd.).
Mr. S. A. Main (Hadfields, Ltd.).
Mr. T. M. Service (Wm. Beardmore and Co., Ltd.).
Mr. J. H. Whiteley (the South Durham Steel and Iron Company, Ltd.).

The Sub-committee now presents this, its first report. The work is confined to a consideration of the degree and nature of the heterogeneity found in carbon steel ingots. This has been made possible through the generosity of the firms, with whom the members are associated, in supplying data and in facilitating and financing a most costly form of investigation.

The report is divided into the following sections:—

SECTION I.—Introduction.
SECTION II.—The methods employed in studying the sectioned ingots.
SECTION III.—Data obtained from representative steel ingots.
SECTION IV.—A general discussion on the heterogeneity found in ingots.
SECTION V.—Bibliography.

The report is a very long one, and in what follows we deal only with Sections I. and IV., both with some abridgment.

SECTION I.—*Introduction.*

A knowledge of the degree of heterogeneity which is to be found in steel ingots of all kinds and of the manner in which it arises is of much interest, both from the technical as well as from the scientific point of view. For certain types of engineering projects developed during the last few years increasingly heavy ingots have been required and made, and the variations in the mechanical properties and chemical composition have sometimes proved disconcertingly wide. It has long been generally understood that as the mass of the ingot is increased, the heterogeneity becomes more accentuated, and one of the objects of the Sub-committee has been to give a more quantitative expression to the degree of heterogeneity which may be reasonably expected. The evidence shows the variation in composition to be of such an order that the facts should be made known, as they are of the utmost importance, both to steel makers and the users of ingots. The evidence presented is derived from the examination of a large number of ingots ranging from 15 cwt. to over 172 tons in weight. All of them may be regarded as reasonably representative of the type of ingot and the class of steel to which they belong when manufactured under good conditions.

It is sometimes considered that the heating of steel ingots and maintaining them at high temperatures for long periods of time, preparatory to forging and rolling, will, to a large extent, remove the heterogeneity, the idea being that prolonged heating brings about homogeneity by the diffusion of the elements segregated in the cast state. Such an opinion, however, requires considerable modification, in view of the fact that some of the larger examples studied display pronounced heterogeneity, notwithstanding that they have been reheated and bloomed prior to sampling for analysis, thus clearly indicating the degree to which heterogeneity exists after such prolonged heating of the ingot.

It may first of all be stated that no ingot ever produced is completely homogeneous, however carefully the steel may have been made and cast. Further, the intensity of the segregation increases with the size of ingot, as is shown by the increasingly wide variation in the carbon, sulphur, and phosphorus throughout the mass.

The internal character of an ingot is naturally profoundly affected when the liberation of gas during solidification is sufficiently rapid to result in the formation of blow-holes, but such incompletely "killed" steel will not be dealt with in this report.

The metallographic study of a longitudinal section of any ingot made from steel which has been refined or treated so as to solidify without the formation of blow-holes, reveals the following phenomena:—

(1) A very thin extreme outer skin of ill-defined

* Iron and Steel Institute. To be presented at the adjourned meeting on June 3rd.

crystalline structure is generally observed—*i.e.*, true chill crystals.

(2) From the inner surface of this very thin layer a growth of columnar crystals appears, extending inwards—Zone 1. The thickness of this layer will depend upon the temperature of the liquid steel, rate of teeming, the temperature, thickness, and nature of the mould, the size of the ingot, and composition of the steel.

(3) Proceeding towards the centre of the ingot, it will be found that beyond the zone of columnar crystals lies a region richer in segregates, the segregate usually occurring in the form of spheroids or thin strings. This zone of segregation—Zone 2—is of annular form, its inner boundary having roughly the form of a truncated cone or pyramid, according to the shape of the ingot.

(4) Sulphur prints and etchings show that inwards from Zone 2 there is a central zone—Zone 3—in which the crystals may cease to possess the hitherto well-marked columnar form. In the lower half of this zone the steel is lower in carbon, sulphur and phosphorus than the original liquid steel—the lower central axis is, indeed, the purest part of the ingot. In the upper half of the ingot this central zone approaches the average composition of the steel, but in many cases local segregation appears within it, assuming frequently a roughly V-shaped form.

(5) At the extreme upper end of Zone 3 there is a region of segregation.

(6) The axial portion of the ingot is always rather unsound, and, except in the lower part, seldom quite free from segregation.

(7) Unsoundness is sometimes found, though to a less degree, in vertical planes radiating to the corners of the ingot and in inclined planes from the edges of the base of the ingot.

With two exceptions, the ingots dealt with have been cast in chill cast iron moulds. One small ingot was cast in a sand mould, the other in a mould lined with a refractory "composition." The comparison of these two ingots with those cast in chill iron moulds is of interest for two reasons. In the first place, the effect of the absence of the normal chill is observable, and in the second a clear indication is given of the degree of heterogeneity which is likely to occur in ordinary steel castings.

It is not within the scope of the present report to indicate or to suggest modifications in the process of manufacture with a view to modifying the degree of heterogeneity, but only to present to the members an accurate indication of the degree which may reasonably be expected in ingots representative of the present state of the art of steel manufacture. Although steel makers have for many years devoted much time, study and expenditure to the problem, it is felt that much more remains to be done in investigating the causes of heterogeneity, particularly as regards fundamental data, and it has been the endeavour of the Committee to increase the knowledge at present available on the subject.

SECTION IV.—*A General Discussion on the Heterogeneity Found in Steel Ingots.*

The preceding Sections I., II., and III., dealing with observed facts, have the unanimous concurrence of all members of the Committee. This Section IV., dealing as it does with the theoretical aspects of the problems involved, is a collective attempt to present various ideas worthy of consideration when an explanation of heterogeneity is being sought; the ideas put forward have not necessarily the unanimous support of all the members of the Committee.

In attempting to explain the heterogeneity existing in all cast masses of steel, the investigator experiences extreme difficulty in distinguishing between the various influences at work and in determining their comparative effect. The members of the Committee have individually and collectively endeavoured to form a picture of the mechanism of freezing with a view to accounting for the lack of homogeneity found in the various ingots. Complete agreement on all the aspects of the matter was hardly to be expected and was not attained. The following observations, however, will be of interest, as indicating the trend of the ideas put foward, and will, it is hoped, be of value to others who may seek to carry the matter further.

A consideration of the subject is rendered most difficult by the paucity of available physical data concerning the properties of iron in combination with the other elements present in the liquid state and at temperatures near the freezing point. Thus, with few exceptions, the equilibrium diagrams are not yet definitely established. Further, it is not yet known whether, or to what degree, there is a modification in the density of the steel when it freezes. The experimental difficulties in the way of such determinations are considerable, but it is hoped that investigators will, in the near future, be able to deal with this and allied problems.

(*a*) Steel is not a simple metal; in its liquid form it is a solution of the other elements or their compounds present in the iron. When solidification begins the crystals which constitute the primarily formed solid steel are solid solutions of these same elements or their compounds in iron, but, owing to selective freezing, according to well-known laws, they are of a greater purity than the original liquid. The remaining liquid steel must therefore become progressively richer in these compounds, and probably of lower density than the original steel.

The data presented indicate that all ingots, no matter what their size, relative proportions, method of casting, or processes of manufacture, show segregation of certain elements in well-defined zones. Further, that the degree of segregation is highest for the elements carbon, phosphorus, and sulphur, but is almost negligible for manganese and silicon.

Another very important factor in this process of differential or selective freezing is the *rate of cooling* through the freezing range. It is considered by some that, as the speed of cooling becomes less, the tendency to heterogeneity will diminish because more time is available for the diffusion of the constituents into the purer crystals first formed. It is, however, to be deduced from existing diagrams that the differences of composition p_2 and q_2 for the crystals and liquid respectively, at temperature t_2 represent the compositions only when equilibrium is established, and for this very slow cooling is essential. If the cooling is rapid there is not the requisite time for the complete separation of the two phases, and the less marked is the heterogeneity of the crystals; the slower the cooling through the freezing range the more marked are the differences in composition.

This effect is of particular importance. First, in all ingots the outer layers pass through the freezing range very rapidly on account of the great absorption of heat by the mould, and there is not sufficient time for the phases to separate; hence the crystals of steel formed show little or no variation in composition: there is little segregation. As the rate of cooling falls, the time occupied in passing through the freezing range increases and the variations in composition become more marked; it is suggested that in the central zone, where presumably the rate of cooling is slowest, the separation of the phases is the most complete and the crystals show the lowest percentages of the segregating elements carbon and phosphorus.

Secondly, the cross-sectional area of the ingot has a fundamental bearing upon the process; the greater the diameter of the ingot the slower must be the rate of cooling of the interior portions, and therefore the more marked will be the differences of composition observable.

From such considerations it appears that even steel made under the most perfect conditions, perfectly free from extraneous material and of uniform composition when entering the mould, must exhibit, when solid, certain variations of composition because of this selective freezing. The degree to which these variations manifest themselves will increase:—

(1) As the carbon and phosphorus content of the steel increases;
(2) As the rate of freezing of the ingot falls; and
(3) As the cross section of the ingot increases in dimensions.

The factors governing the segregation of sulphur require separate consideration. So far as can be ascertained from the studies already made on the question, it is very difficult to assign any definite composition to the sulphide which is present in liquid or solid steel.

Sulphur mainly exists in the liquid steel in the form of minute globules of an immiscible, complex sulphide. During the rapid formation of the columnar crystals in an ingot, these globules are pushed farther into the interior of the ingot by the growing crystallites, and as a result there is an increase of the sulphur content in the layer of mother liquor at the face of crystallisation. The small globules coalesce and comparatively large masses collect at the tips of the columnar crystals. These, by virtue of their lower density, commence to rise, but are entangled by the growing crystals, and hence give rise to the first zone of segregate, which is found as string-like masses at the surface of the columnar crystals.

In the mass of the still liquid steel of the ingot a similar process occurs. The small globules of sulphide coalesce and tend to rise, the larger the globule the quicker being the rate of rising. The globules from the central or axial parts of the ingot rise into the upper portion and ultimately into the head, leaving the lower, central zone much lower in sulphur than any other zone. In the intermediate zones, between the columnar crystals and the axial zone, the sulphur segregate will not be able to rise as far as the head before it is trapped by the continuously advancing wall of the ingot as freezing proceeds. The particles in the outer zones will have but a small period of time to rise, and therefore only travel a short distance before the thickening wall intercepts their further progress. The nearer the particles are situated to the axis of the ingot, the longer periods will they have for rising, and therefore the farther will they proceed in their journey towards the head before being arrested by the solidifying steel shell of the ingot.

If this picture be correct, then it would be anticipated that the lines of segregate or ghost lines would show a gradual taper inwards as they pass from the bottom corners of the ingot towards the head, and that the degree of segregation would become more pronounced as the head is approached. Such is experimentally found to be the case.

A further point of interest arises from these considerations. A study of the segregated areas shows that although the segregation of carbon, manganese, silicon, and phosphorus proceeds by a physical law different from that governing the segregation of sulphur, yet the elements carbon, sulphur, and phosphorus are invariably found to segregate together.

(*b*) As already stated, after teeming the cooling of the steel at first takes place chiefly by absorption of heat by the mould walls. Subsequently, cooling proceeds by transmission of heat through the mould, which heat is radiated from the outer surface. These two cooling actions occur simultaneously, but the first starts from a maximum value and decreases with time, and the second starts from zero value and increases with time up to a certain point, when it slowly decreases again. The first action is capable of freezing, at any particular section of the mould, a considerable mass of steel. Subsequent cooling by conduction through the mould may be, under some conditions, slightly more rapid at the top, owing to its thinner section, than at the bottom, and therefore the isothermal lines otherwise parallel to the surface may tend to become modified. Broadly, however, the freezing of an ingot can be considered to occur in three successive periods:—

(1) Almost instantaneous freezing.
(2) Very rapid freezing.
(3) Comparatively slow freezing.

The duration of these periods depends, as previously indicated, upon the rate at which the heat escapes from the solidifying steel.

The effect on the nature of the crystallisation of the rate at which heat is removed by the surrounding mould will obviously depend upon the conductivity of the steel, since up to a certain point, depending also upon the thickness of the wall of the mould, the more rapid the transference of heat from the interior, the greater will be the chilling effect. The heat conductivity of steels of different compositions undoubtedly varies, and therefore a better knowledge of the conductivity of steels both in the liquid and also the solid state, and of steels of different compositions, at all pertinent temperatures is essential. The possibility and extent of convection currents within the still fluid portion of the ingot, as freezing continues, is also connected with the conductivity. Again, the rates of diffusion of the various impurities in the solid and molten steel, which must also be taken into account, are unknown. The position, too, of the liquidus and solidus of the quaternary system Fe–C–P–Mn, which has an important bearing, has not yet been determined, even for the small area covering steel compositions. No idea can be formed, therefore, of the degree of segregation to be expected in different steels and under widely varying cooling conditions, except from investigations similar to those under discussion. The reason why manganese and silicon segregate very slightly, if at all, may be due, as previously suggested, to a very rapid diffusion of these elements.

Whilst dealing with these matters it is well to put on record the possibility of another influence in producing heterogeneity. It may be shown that, as a result of the known laws governing osmotic pressure, temperature gradients in a solution will influence the distribution of the solute. In a dilute solution the osmotic pressure is proportional to concentration and to absolute temperature. The rate of diffusion, *i.e.*, the rate of segregation, will depend upon temperature gradients as well as upon the actual temperature differences. As to whether liquid iron solutions such as those under discussion can be considered to behave in an analogous manner can only at present be considered as within the realm of conjecture.

One curious effect noticed in steel ingots of all the sizes dealt with in the present Report is that the columnar crystals do not grow inwards in a direction exactly normal to the chill face, as might be expected, but have a definite upward trend. It has been suggested, as a result of experiments with stearine ingots, that this upward direction is given to the crystallites first forming at the chill surface as a consequence of very local outward curvature of the isothermals in the steel at the outer edges of the rising surface. Once this direction has been given, it is continued in each growing columnar crystalline grain. It is interesting to observe that the upward trend is much more marked in wax ingots which have been slowly poured by means of a small nozzle, in the same manner as steel ingots, than in others where the mould has been filled in a few seconds by decanting the molten wax direct from a beaker.

(*c*) The columnar region having formed, the interesting position is reached at which marked heterogeneity begins to be apparent. The liquid steel existing in proximity to the already frozen columnar region is apparently richer in carbon, sulphur, and phosphorus than the original liquid steel. The higher concentration of the elements mentioned in this zone appears to persist in contrast to the average composition of the remaining body of liquid steel, and continues to do so in some degree until solidification of the ingot is complete. As a result of the reactions in the steel-making furnace, there exist to a greater or less degree oxides dispersed through the liquid steel in a more or less colloidal form. "Manganese sulphide,"* which is held to be insoluble in liquid steel, is also dispersed in a similar manner, and it is an interesting and demonstrable fact that, in the region of high concentration adjoining the surface of the columnar growth, the sulphides, as one would expect, and the oxides also, as suggested by some, appear to segregate. As the growth of the columnar crystals proceeds, the degree of the concentration of the oxides in the adjoining liquid steel naturally increases, and zones of segregate become emphasised, and the non-metallic matter coalesces. Some of the segregate and non-metallic matter is entangled in the tips of and between the growing crystals, and some apparently rises by virtue of lower density. When the ascending segregates are impeded by the growing crystals, they tend to elongate and form typical string-like formations of segregate known as "ghost lines." If this description be correct then the position and the extent of the first zone of segregation will depend upon the depth to which the early columnar crystals are produced, which indeed would seem to be the case.

It has been suggested that, following the formation of the columnar zone, equiaxed crystals of relative purity begin to form in the central portion of the ingot and fall towards the bottom. It results from the relative positions of the liquidus and solidus in the equilibrium diagram for the binary system of iron and carbon or carbide, that if there is a small variation in temperature and composition between the liquid centre and the freezing wall of the ingot, say, 20 deg. Cent., then it is possible while the walls are continually growing at the lower temperature for purer free crystallites to form in the interior liquid at the higher. It further seems reasonable to assume that such crystallites, being perhaps heavier, will tend to settle and become mixed with those growing on the bottom. A central zone purer than the average metal would them be formed in the ingot, and this zone would necessarily be conical in shape. Owing, however, to the absence of sufficient physical data to enable unanimity to be reached as to whether or not it is likely for such crystals to form and fall to the bottom, it is simply put on record that this is one suggestion which has been made, with a view to explaining what is actually found—viz., that the "ghosts," or segregated strings, tend to slope towards the centre of the top of the ingot, simply because such liquid portions of high concentration become trapped between the columnar zone and the centre area of free crystallites which rests on the base; in continuation of which idea it is noted that the inner boundary of the "ghost" zone tends to slope towards the central axis of the ingot as one examines it from the bottom upwards.

(*d*) Whilst the columnar region is being formed the steel is contracting by the general cooling effect. As a result, at a certain stage, governed by the size and nature of the mould, and the nature of the steel, portions of the shell of solid steel separate from the wall of the mould, as is commonly observed in the casting of ingots, and a gap is formed between the two. Up to this point heat has passed outwards through the growing layer of solid steel and the walls of the mould by a continuous process of conduction. As soon as the gap is formed this conduction becomes discontinuous, and cooling takes place practically only by radiation from the ingot to the mould. Under these conditions a marked reduction in the rate of heat transference must occur, and with it a distinct retardation in the rate of freezing of the remaining liquid steel. It is suggested that this factor is largely responsible for the change in the type of crystal from the columnar to the equiaxed type.

It may be thought that the explanation of the change in type of crystallisation, which depends mainly upon the

* MnS is here used as an empirical description covering all those inclusions which are largely composed of MnS.

separation of the shell of solid steel from the walls of the mould, is not at all adequate or satisfying. Small test ingots, although necessarily always cooled very rapidly owing to their size, can have, under suitable conditions, principally of casting temperature, a large porportion of equiaxed crystals, as shown by the fracture. What the actual explanation of the critical change from columnar to equiaxed is, it is difficult to say, but casting temperature seems to be in some way a dominant factor. In the explanation mentioned also not enough is perhaps made of the fact that the first solidified portions of the ingot must themselves very greatly slow up the rate of cooling of the remaining fluid steel, as conduction will not go on very readily through steel at such a high temperature; and, further, the liberation of the latent heat of freezing must have a retarding effect.

This change in rate of cooling cannot, however, alter the general nature of the process of freezing. The major portion of the heat from the liquid steel passes out through the walls and base of the solidified steel and mould. The outer layers of liquid in contact with the solidified steel may be considered to be the coldest portion of the remaining liquid, and freezing, however slow, to proceed as previously from the already solid shell, except, for instance, where differential composition in the liquid phase may produce crystals at temperatures above the freezing point of the segregated material. It must, however, be borne in mind that in very large masses this frozen contour may be modified. In examples placed before the Committee, etched sections from ingots even of large sizes showed a continuation of the columnar crystal axes from the surface to the centre of the ingot, there being no apparent break at the change from the columnar type to the free crystal.

As this crystallisation proceeds on the thickening walls of the ingot, the crystals deposited or growing must still be purer than the liquid steel, and the layer of liquid in contact with this wall must have a higher concentration of those elements in solution than the remaining liquid. This layer of less pure liquid steel will be subject to two tendencies. In the first place, it will tend to rise towards the head of the ingot, owing to its possibly lower density; and, in the second place, the carbon and phosphorus in this layer will tend to diffuse into the remaining liquid steel, a process which will continue for some time after solidification. It is experimentally demonstrable that the former tendency predominates, as examples have been before the Committee in which liquid segregate had clearly arrived in the head of the ingot some considerable time before solidification was complete. Two processes, then, are proceeding simultaneously—the segregate is rising, and the walls of the ingot are growing inwards. It has been suggested that, as a consequence of the segregate rising, there is presumably a responsive downward movement elsewhere. As the segregate rises it will be trapped at various points nearer and nearer to the centre of the ingot by the in-growing crystals as the head of the ingot is approached, thus giving the truncated cone of segregation. As the rate of cooling falls the speed of crystallisation decreases, the time available for the rising of the segregate will increase, and thus separation from the growing crystals will be more and more complete.

In the upper half of the ingot this purification by separation of the segregate will be more than balanced by the segregate rising from below, and hence the increased concentration of the constituents in this zone.

At a certain stage in the cooling of the freezing ingot the temperature of the remaining liquid will approach the freezing point and it will become very viscous. The tendency of the segregate to rise will therefore be materially reduced. On the other hand, the liquid steel and segregate remaining in the head will tend to be drawn down the comparatively narrow central channel of remaining liquid steel, to counterbalance the contraction due to loss of temperature. The segregated material will thus be drawn with it, giving rise to the V-shaped zones on the central axis of the ingot, which would explain the sagging effect generally observed. It is well known that the extent to which this occurs depends largely, apart from casting temperature, upon the amount of hot and liquid steel maintained in the head of the ingot for the purpose of filling the cavity which the freezing steel tends to form. The size and shape of the ingot are also variables of considerable influence. It will, of course, be seen that this drawing down of the segregate forms further evidence of the separation of the segregate which must have taken place to permit it to have risen and collected in the upper portion of the ingot.

It will thus be clear that the amount and position of the central segregate can be controlled to some extent by the use of various factors; on the contrary, the conical segregate seems stereotyped and difficult to mitigate.

From the foregoing it will be evident that the last portion to freeze in the top of the ingot must of necessity be richer in segregate, of lower density, and, as naturally follows, of lower melting point.

As regards the unsoundness along the central axis of the ingot and elsewhere, it is suggested that this is due to the meeting of, and loose cohesion between, the differently oriented systems of crystals growing from the walls and base of the mould. These planes and lines of weakness are associated with planes of segregation, which affords evidence in support of the general view as to the manner in which the heterogeneity comes into existence. If the crystals formed are purer than the mother liquor, and therefore leave a more impure liquid, *i.e.*, segregate, on the plane of crystallisation, then whenever two such planes meet there should be, as is indeed found, a collection of segregate. Further, the fact that the central axis is always a zone of looseness or weakness, seems to be direct evidence in favour of the progressive crystallisation from the surface to the centre of the ingot. Such a process would obviously leave a central zone of weakness, whereas if the crystallisation were simultaneous throughout the central or free crystal zone, as is supposed by some, there is really no very apparent reason why there should be any central weakness.

DITCHLING'S 200-year-old windmill is to be purchased by the Sussex Archæological Society, and preserved as a type of the original peg and post mill.

Opening of the New Esholt Sewage Works.

THE formal opening of the new Esholt sewage disposal works of the city of Bradford took place on May 5th last, Mrs. Johnson—wife of Alderman Richard Johnson, J.P., chairman of the Sewage Committee—performing the ceremony. The opening of the penstock at the head of the syphon, thereby releasing the waters across the Aire Valley, marked the completion of an important section of the new works, and has made possible the final abandonment of the old Frizinghall sewage works. Thus has been brought nearer to solution a problem which has claimed the constant thought, not only of Alderman Johnson during his chairmanship extending over eighteen years, his deputy chairmen and Committees, but also that of the late Sewage Works Engineer, Mr. Joseph Garfield, M. Inst. C.E., covering a period exceeding twenty-five years, and of his staff.

For use at the ceremony a brochure had been prepared, and from it the information contained in the following has been prepared. The works at Esholt are not finished, but the accommodation for sewage treatment now far exceeds that hitherto available at Frizinghall. Because of that circumstance, and because the tunnel connecting Frizinghall with Esholt and also the syphons crossing the Aire Valley are finished, the starting up of the new works is possible. The immediate effect is two-fold. The Bradford Beck and the river Aire for a length of 4½ miles will no longer suffer pollution by reason of the Bradford sewage, and the sewage effluent entering the river Aire in the neighbourhood of Esholt Hall will be of a better quality. As the years go on, by reason of the extended accommodation provided for in the complete scheme, the quality of the final effluent will show continual improvement.

The estimated cost of the scheme in 1907 was £955,000, but owing to the higher markets for labour and materials, the cost is now estimated at approximately 2¼ million pounds, both figures being exclusive of land. To March 31st last 1¼ million pounds had been expended, so that it will be seen that although the works have been opened, little more than half has been completed. The Esholt estate, purchased from the Misses Stansfield in 1905, covering 1700 acres, at a cost of £239,742, has from time to time been increased to a total net acreage of 1866, costing £301,000. The total cost of the original scheme, with land, therefore, will now amount to approximately 2½ million pounds.

The chief works remaining to be completed are the storm water tanks, precipitation tanks, filters and sulphuric acid plant. The storm water tanks should deal with 60 million gallons of storm water on the basis of the 1907 flow of sewage. It will not, however, be possible fully to treat that volume of storm water at present, because the whole of the tanks are not yet available, and the area of the precipitation tanks so far constructed being insufficient, the storm water tanks will be required for crude sewage. The precipitation tank accommodation now ready for use at Esholt is double that operated at Frizinghall, but it is still only half the required capacity on the basis of the 1907 flow of sewage. To safeguard the filters, it will be necessary to restrict the flow of crude sewage to the new precipitation tanks. One-third of the filters has been completed and is capable of dealing only with an equivalent volume of the 1907 flow. The foundations of the sulphuric acid plant have been commenced, and it is intended to proceed with the erection of the first unit at an early date.

The experimental trials of the operation of the new works revealed no errors in levels, the waters behaved in the way expected, and were subject to control as designed. It will, however, be a matter for future consideration how far the increased volume of sewage in 1926, as compared with the flow in 1907 when the scheme was designed, will affect the capacity of any section of the works to deal with the final purification of the sewage adequately.

The cleaning of the syphons has received careful attention. A method of keeping the syphons clear of deposit is the use of a solid wooden ball, 14 cwt. in weight, which is passed through the pipe lines from the south to the north side of the Aire Valley, a distance of 693 lineal yards, and takes less than ten minutes to pass through. The ball is 3ft. 9in. in diameter—3in. less in diameter than the pipes through which it travels—and is weighted to float low in the water—that is, the specific gravity of the ball is only slightly less than that of water. In passing through the pipe line, driven forward by the flow of sewage, the ball rubs along the upper surface of the interior of the pipe, leaving a cavity of 3in. below. The slight retardation of the ball owing to frictional resistance causes an increased velocity in the liquid passing under the ball, this having the effect of stirring up and driving forward all the silt until the ball and the silt emerge at the outlet end, thus clearing the syphon.

The business side of sewage treatment is of more than passing interest. In the year 1903 grease recovered from the processes of sewage disposal was put on the market for the first time, and realised the sum of £222. In 1905 dried sludge was first sold as a commercial article for use in connection with fertilisers, and the sum of £33 was received. The sale of these by-products has grown considerably. In 1918 the sum of £136,274 was realised, being the largest annual sale, and was due to exceptional conditions. It is, however, worthy of note that November 26th last marked the completion of sales totalling one million sterling.

The main outfall sewer from Frizinghall is 10ft. in finished diameter, circular and in tunnel for 2¾ miles. It has a gradient of 1 in 2000, and is capable of discharging 180 million gallons of sewage per twenty-four hours. The first contract was let to Pethick, Dix and Co., in 1913, who failed, for financial reasons, to complete the work. In 1914 the Corporation completed the shafts by direct labour. In 1915 and 1916 John Best and Sons (Edinburgh) carried on the work under a new contract, but war measures prevented the continuance of the operations. In 1919 the Corporation undertook to do the work by direct labour, the hill being successfully pierced on May 14th, 1923. In September of the following year the tunnel was completely finished, and the connecting sewers at Frizinghall have since been completed, except for one chamber. The alignment of the tunnel proved to be perfectly accurate from end to end, whilst the error in level was nowhere more than ¼in. The measurement on the centre line showed the tunnel to be only 3in. longer than the figure of the original survey. The tunnel is lined with one ring of blue bricks backed up by concrete, the thickness of the lining being 18in. on the average.

The valley crossing consists of two lines of 48in. cast iron pipes passing from the south to the north side of the Aire Valley, 693 lineal yards in length. On the south side there are vertical shafts 68ft. in depth, after which the pipes pass with a very slight gradient beneath the canal, over the river Aire supported by a reinforced concrete bridge, and from thence up a gradient of approximately 1 in 5 and 1½ to 1 to the precipitation tanks. The syphons are safeguarded for cleaning purposes by the provision of wash-outs at the lowest point, and hatch boxes as a means of ingress to the interior of the pipes, while the design has so been arranged that the cleaning of the syphon by means of a wooden ball is made possible. Each line of pipes is capable of delivering 38 million gallons of sewage to the precipitation tanks.

The detritus tanks consist of a self-cleansing apron delivering the heavier class of silt into a detritus pit of half a million gallons capacity, which is kept clear by dredging. The sewage then passes through a battery of eight screens to the detritus tanks, which are two in number, each capable of holding half a million gallons. After passing through these two tanks, the sewage passes over weirs so that the flow can be accurately measured by Lea recorders. The detritus tanks are designed to take the whole of the flow for measuring purposes, after which the storm water is separated in the storm water bay, approximately 60 millions going over the storm water weir in wet weather and 30 millions per twenty-four hours going forward through the syphons for full treatment.

The precipitation tanks will have a total capacity of 19¼ million gallons. They are divided into two parts, twenty of the tanks having an average depth of 7ft. 8in., and the others having an average depth of 10ft. 2in. This second series of tanks has been arranged with a rising and falling water line, so as to act as a storage reservoir for the steady supply of liquid to the filters. Arrangements have been provided for the sludging of the tanks and for passing the deposited material down to the sludge disposal plant. Acid storage has been provided on the site of the works, in addition to which commencement has been made to construct the first section of plant for the manufacture of the acid on the spot.

The tank effluent conduit between the precipitation tanks and the filters follows along the eastern side of the Esholt estate, and has a length of 920 lineal yards. This carrier has a fall of 1 in 2000, and is rectangular in shape. It is a covered channel with a reinforced concrete roof, so as to exclude all dust and other extraneous matter, and is capable of discharging 125 million gallons of sewage per twenty-four hours. The water from this channel discharges into a screening chamber, where it is further finely screened before passing forward to the filtration area.

The foundation of the sludge disposal buildings was laid on September 20th, 1910, and the buildings were opened on September 24th, 1912. They contain 128 presses, sixteen grease vats, a battery of four "Stirling" boilers, air compressors, and other plant, all designed to deal effectually with the processes of sludge pressing and grease recovery.

A branch railway from the London, Midland and Scottish main line to the works was opened for traffic in 1910, and since then for construction purposes some 18 miles of further 4ft. 8½in. gauge track have been laid on the estate. A canal basin has been constructed and is capable of berthing four barges.

The storm water tanks are seven in number, and average 6ft. deep, with a total capacity of 11¼ million gallons. They discharge through a 4ft. diameter pipe line to the river, the latter having a gradient giving ample discharging capacity. The intercepting sewer from Eccleshill and Idle is 2ft. 4in. by 3ft. 6in. high. It is egg-shaped, and was constructed in tunnel for one-third of a mile. It has a gradient of 1 in 630 and is capable of discharging 12 million gallons of sewage per day.

The scheme so far includes for 60 acres of bacterial filters, estimated to be the requirements to purify the 15 million gallons of dry-weather flow, plus, in times of wet weather, an equal volume of storm water.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

IMPROVEMENT IN BOILER DESIGN.

SIR,—In a leading article on "Improvement in Boiler Design," published in your issue of April 30th, on pages 499 and 500, you criticise the method of high-pressure steam generation proposed by *me*, but do not take account of the fact that the transmission of heat from the fire gases to the heat-carrying medium, whether water or highly superheated high-pressure steam, especially depends on the heat transmission between the hot gases and the wall of the boiler or tubes. The rate of heat transmission from the gases to the water is consequently but little different from that of the heat transmission between the gases and highly compressed steam, while the heat transfer to steam of low pressure is much less favourable.

In boilers of ordinary type the steam is finally superheated. The ordinary superheaters, however, suffer from the disadvantage that they get burnt at once if the steam consumption of the engine diminishes and the steam ceases to flow, provided they are not disconnected at the proper time. The latest developments of boiler construction require that boilers shall work at the highest superheating temperature possible, and the superheater is placed in the combustion space of pulverised coal furnaces, where it cannot be disconnected save with very great difficulty. In my method of steam producing, the safety of the superheater is much more secure, because, owing to the forced circulation of steam, at any time, and even in the case of reduced steam consumption, steam passes through the superheater, which therefore is entirely protected from being burnt.

The steam circulating pump is of very simple design, and has

to pump saturated steam only. The high pressure of this steam is not objectionable or dangerous at all, for the pump has only to work against the difference of pressure on the two sides of the piston, which difference is very small—about 30 lb. to 45 lb. per square inch. The pump therefore is safer than any boiler feed pump for warm water.

While in ordinary boilers the heat transmission is uncertain and uncontrollable, because for high pressures the drums, with the numerous tubes expanded into them, must have shells of enormous thickness and noxious accumulation of heat therein is avoidable. In boilers on my system a constant flow of heat is secured by the forced steam circulation, and can be controlled at every moment of service. This feature highly improves the safety of working and can certainly not be considered as retrograde.

The method of steam generating advocated by me cannot be carried out at low steam pressures, and for that reason no doubt it has not been employed up to to-day. At low pressure, on account of the large specific volume of the steam, the power needed for the steam circulating pump is too large for economic working of the boiler. Only at pressures exceeding about 700 lb. per square inch the pump power becomes sufficiently small, and at pressures of 1500 lb. to 1800 lb. per square inch it only requires about 2 per cent. of the available boiler power.

May 10th. H. LOFFLER.

WATER-COOLED COMBUSTION CHAMBERS.

SIR,—Makers of pulverised fuel apparatus are frequently asked to supply or to advise as to the design of combustion chambers to be employed, and are doubtless willing to do this as far as lies in their power, but when the inquiry is for a water-cooled combustion chamber the question at once arises as to whether this is not for the boilermaker rather than for the maker of the pulveriser. When the elements for cooling the combustion chamber are tubes containing water or steam at boiler pressure, the boilermaker has in some cases objected that the satisfactory working of the boiler may be prevented by defects in the combustion chamber, for which he must not be held responsible, and so forth: that his boiler is perfect as it is, but that no one knows what will happen when the combustion chamber tubes are connected up to it, and that he washes his hands of it, &c. &c. The water-cooled combustion chamber has undoubtedly come to stay, and it seems obvious that it forms part of the heating surface of the boiler just as much as any other part of the boiler, and is, in fact, just a development of boiler design which should be adopted by the boilermaker and made and guaranteed by him. The water-cooled chamber is as much a fire-box as that of a locomotive, and should be looked upon as such. The present detached attitude of the boilermaker seems to be out of harmony with the natural trend of progress in boiler design, and the final result, both as regards the boiler and the combustion chamber, would be much better if this aloofness were to disappear, as each element would then be adapted and made to suit the special circumstances pertaining to the other. One or two boilermakers have adopted this view, and are offering water-cooled combustion chambers as part and parcel of their boilers, and it is to be hoped, in the interests of economical steam generation, that the remainder will follow suit without delay.

P. V. VERNON.

Coventry, May 5th.

MOTOR TRAINS.

SIR,—In your issue of last week, under the head of "Railway Matters," it is stated that the late Mr. Dugald Drummond originally introduced trains of the motor car type. This statement is not correct, and this class of train was first introduced on railways by Mr. William Bridges Adams, in the year 1847.

Mr. Adams constructed the steam carriage Fairfield for the G.W.R., who put it to run on the branch line from Tiverton to Tiverton Junction, in Devonshire, in the year 1848. The Fairfield was afterwards taken to Weston-super-Mare to work between there and the old junction on the B. and E. main line in about the year 1850.

The Fairfield was, of course, constructed to run on the broad gauge, and its engine, boiler, also carriage body were all fitted on the one frame, also the general design was very similar to that of the present-day steam cars running on the G.W.R. and other railways. The engine was of the vertical type, fitted with two inverted cylinders. The crank shaft ran in bearings secured to the frame, and the power was transmitted to the driving wheels by horizontal coupling-rods connecting them to the crank shaft, which was fitted with a crank at each end for this purpose. The boiler was also of the vertical type. WM. HY. ROBSON.

London, April 27th.

[We thank Mr. Robson for his note. To be strictly accurate, we ought to have said that Mr. Drummond re introduced the steam coach. It is of some interest perhaps to note that in the L.N.E.R. coaches vertical engines and boilers—the Sentinel arrangement—will be used just as they were in Bridges Adams' coach.—ED. THE E.]

STARTING UP STEAM PLANTS.

SIR,—Referring to your correspondent "H. D.'s" letter in your issue of April 23rd, regarding steam-driven auxiliaries in power stations, the objection to the steam-driven plant has, I think, mainly been that small turbines or high-speed engines have a rather heavy steam consumption, and it has not been found possible to utilise the exhaust from them to advantage. With the introduction of pre-air heaters and utilisation of the flue gases for this purpose, less heat is available for feed water heating, and I should imagine that in cases where air heaters have been installed the whole of the exhaust or nearly all could be used for feed-water heating, obtainable from the turbine or engine driving fans or pumps.

The wide range of speed control which can be obtained from a turbine or engine driving an induced or forced draught fan makes the steam-driven unit very suitable, and renders it particularly useful in cases where the electric supply is alternating current.

A. FLEMING BROWNE.

London, S.W. 1, May 6th.

SIR,—I am obliged to you for sending me Mr. Fleming Browne's letter. In reply, I need only say, as mentioned in my letter, that the turbines were an alternative drive, to motors, for the auxiliaries, and were only used in cases of emergency, so that economy of steam was of little importance.

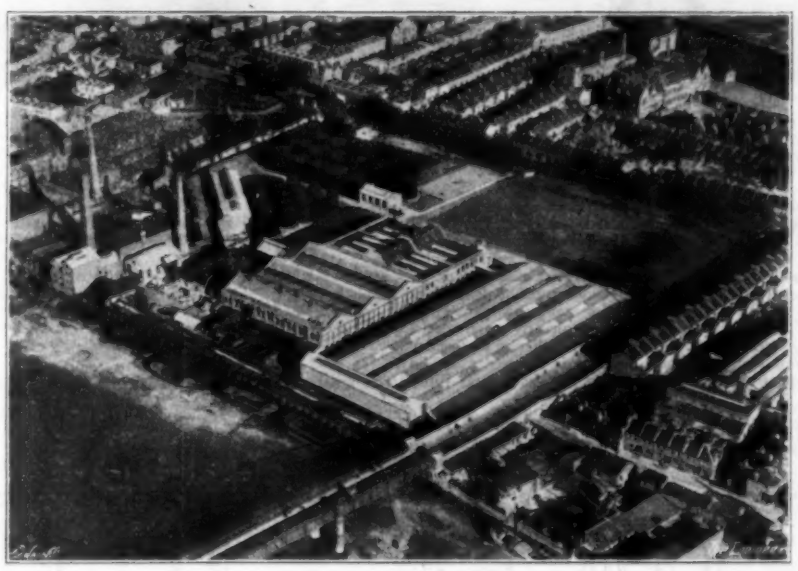
May 12th. H. D.

A Lubricating Oil Depot.

AMONG the firms engaged in the distribution of lubricating oils which possess works in the Metropolis, the Vacuum Oil Company, Ltd., holds an important position, and it may interest our readers to have some account of the plant and processes employed by that company in preparing oil for the market. The following notes are based on a tour round the London works of the company, but it should be pointed out that the company has another depôt, very similar in many respects, at Birkenhead. In addition to the oil business there, a large amount of work is devoted to the manufacture of grease, for which purpose the Vacuum Oil Company claims to possess the largest plant in this country.

The London works are on the bank of the Thames just above Wandsworth Bridge, and occupy the site of an old brewery; the buildings, however, are all quite modern, as will be gathered from the aerial view which we reproduce herewith. It will perhaps be best first to give an outline of the way in which the oil is handled in passing through the works.

The oil, in various qualities, is imported from America in tank steamers, which anchor "below bridge." It is pumped out into tank barges, which are towed upstream and are tied up alongside the wharf at Wandsworth. One of our engravings shows a tow of barges coming up to the wharf, while from the aerial view it will be seen that they have a comfortable berth at low tide. Running along the quayside there is a system of piping, with connections for flexible hose, together with a steam main, which can be used to supply heating coils arranged in the barges to make the oil more fluid in cold weather. The oil is sucked out of the barges by a set of steam-driven Worthington pumps, and the arrangements are such that four different classes of oil can be handled simultaneously without there being any possibility of one contaminating



BIRDSEYE VIEW OF THE WANDSWORTH DEPOT OF THE VACUUM OIL COMPANY, LTD.

another. The delivery pipes go across the works in a tunnel sufficiently large for a man to work in, and emerge in open trenches among the storage tanks seen in the background.

These tanks, it will be seen, are divided into two distinct groups, one of which is used to receive the oil immediately it arrives, so as to avoid demurrage on the barges, while the other group forms the real storage system. The oil is not, however, transferred from one tank to another until its qualities have been determined in the laboratory, an interior view of which we give on page 526. This laboratory is equipped with a great variety of apparatus for testing the physical and chemical properties of oils, and is kept busy carrying out the routine work of the factory, without taking into account research work, a considerable amount of which is undertaken.

One of the functions of the laboratory is to determine the proportions in which the various oils in the tanks must be blended to secure any desired result, and when that information is obtained, appropriate instructions are given to the compounding, or blending, department. The compounding department is furnished with a battery of tanks fitted with steam heating coils. The various ingredient oils are pumped into these tanks and compressed air is admitted at the bottom for several hours to agitate the mixture and ensure that it is thoroughly homogenous. The outlet from the tank is locked during this process, and it can only be tapped with the permission of the chief chemist, who does not give his sanction until tests of the compounded oil have shown that it complies with the proper standard. The oil is now ready for packing in barrels or tins, and it is in these operations that the more interesting mechanical processes are employed.

The outstanding features of the packing department are the reduction of manual labour in handling to a minimum, and the maintenance of a high standard of cleanliness. The wooden barrels and metal drums which are returned for refilling, for instance, are so thoroughly cleaned, both inside and out, that they have the appearance of being new, and we could detect no odour of oil in a large number of "empties" which we inspected.

Steel drums are steadily replacing wooden barrels for holding oil, but there is still a large proportion of barrels in service, and the two types are dealt with quite separately. Generally speaking, there are some dregs of oil in the returned barrels, and they are consequently first thoroughly drained. The barrels are then rolled forward on a pair of rails and arranged with their bung holes over a series of jets on a steam main. The rails are lowered, so that the nozzles go right inside the barrels and steam is turned on. When the inside has been thoroughly steamed, the rails are lifted again and the barrels roll down a slope to a tank where a wash of weak soda water is poured in and the bung hole is closed. They are then taken to a machine which grips the barrel by the heads between a live and a dead centre—much as in a spinning lathe. The barrel is rotated in a hot soda bath and is subjected to the action of wire brushes to clean the outside, while the inside is, of course, scoured by the internal charge of soda water. After having been trundled in this machine for several minutes, the barrels are rolled forward, between jets of water, to wash off any soda solution, and are drained of the interior charge. The barrel has now arrived in the drying room, in the floor of which there is a number of air pipes provided with upwardly projecting nozzles. The barrels are arranged with these nozzles in the bung holes and hot air is admitted for at least four hours to dry the interior. If, on inspection with an electric lamp, the barrel is found to be thoroughly clean, it is sent on to the cooperage for overhaul. Any faulty parts are replaced and the hoops are driven home by an electrically operated machine.

The barrel is then taken on to another department, where its interior is coated with glue, to make it impervious to oil, and it is painted on the outside in a rotary machine. During the painting process, by the way, the bung hole is temporarily closed with a square of waxed paper to prevent any paint getting inside and contaminating the oil. After being painted, the barrel is taken to another drying room, where cold air is blown into it for several hours to set the glue lining, and by the time this process is finished the outside paint is dry. A final examination is given to the barrel before it is passed on to the filling department to receive its contents.

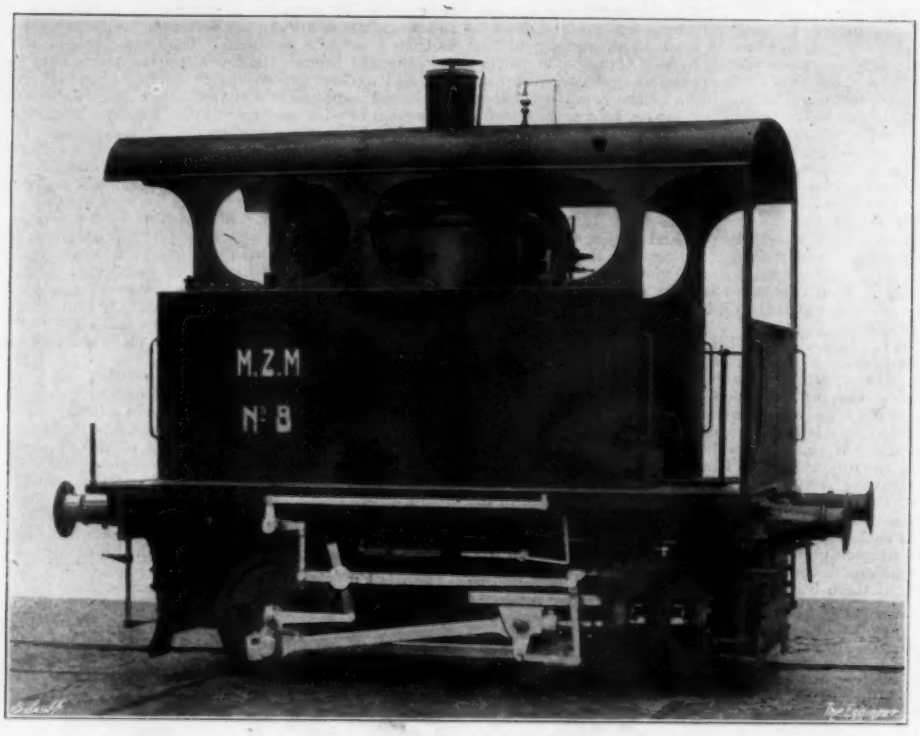
In the case of steel drums, the process is much the same, except that the glue coating is not required, but there is an additional operation before washing out to make sure that there is no scale or rust on the inside. This is effected by slipping a length of ordinary chain into the drum and rotating it in the machine shown in one of our engravings, the action of which is so obvious that it needs no description. The chain can be easily pulled out of the bung hole with a hook, when the cleaning is done.

The clean barrels or drums, together with the new tin cans for smaller quantities of oil, are sent on to the filling departments, which are supplied by gravity from the compounding tanks. The filling is gauged, not by measure, but by weight, and there are several different types of machine for the purpose in the works, but they all work on much the same principle. The empty container is balanced on a weighbridge, and the weight of the required contents is added. Then as soon as sufficient oil has been run into the can the weighbridge sinks and closes an electric circuit, which shuts off the supply of oil. In order to be effective, it is obvious that the stop cock in the oil pipe must be extremely rapid in action, and it appeared to us that the cut-off was almost instantaneous, but we noticed that some experiments were being carried out with a new cock, which, it was hoped, would be quicker even than those now in use.

The filled containers, whether they be barrels or cans, are taken to the warehouse for storage or direct shipment, and in this connection an elaborate system of conveyors and elevators has been installed; but, seeing that the principles involved are common practice, there is no need to enlarge upon them here. There is, however, one other section of the works of interest to engineers, which we also illustrate. It is the power-house, in which there is a pair of high-pressure Browett and Lindley engines driving G.E.C. generators for supplying the power and lighting for the works. The use of such plant, in the place of taking a supply from the public mains, is, of course, justified by the large amount of heating steam required by the various processes, which is supplied by the engine exhaust after the electric power has been obtained from the generators at a nominal charge. The steam is raised in two Babcock and Wilcox boilers, fitted with chain grate stokers and also equipped for burning oil.

INDUSTRIAL LOCOMOTIVE WITH VERTICAL BOILER

LA SOCIETE JOHN COCKERILL, SERAING, BELGIUM, ENGINEERS



Industrial Locomotives.

For many years La Société John Cockerill, of Seraing, Belgium, has held a high reputation as a builder of locomotives of all types, from the largest main line express engines down to the smallest kinds used in industrial works. The firm has, indeed, devoted particular attention to the design of industrial locomotives, and has developed a type of engine with vertical boiler which has proved so successful that more than 1100 are already at work in factories, quarries, contractors' yards, collieries and other places where short-distance haulage is necessary. The general appearance of one of these locomotives is illustrated above. The short wheel base, together with the power and the general handiness of the engine, make it particularly suitable for working on temporary lines, or other tracks with steep gradients, sharp curves and numerous points. A special feature of the design is that the side frames are set outwards in a curved form between the wheels, so that a boiler of considerably larger diameter than would otherwise be possible can be accommodated between them. This arrangement, which is patented by Messrs. Cockerill, makes the use of laminated suspension springs difficult, if not impossible; hence, these locomotives are carried on helical springs interposed vertically between each axle-box and the frame.

The form of locomotive illustrated is built in three standard sizes, known as types III., IV., and V. respectively, type IV. being also built both to a light and heavy design. The engine shown above is of type V. Its arrangement and overall dimensions are given in the drawing while the Table gives the leading particulars of all three types.

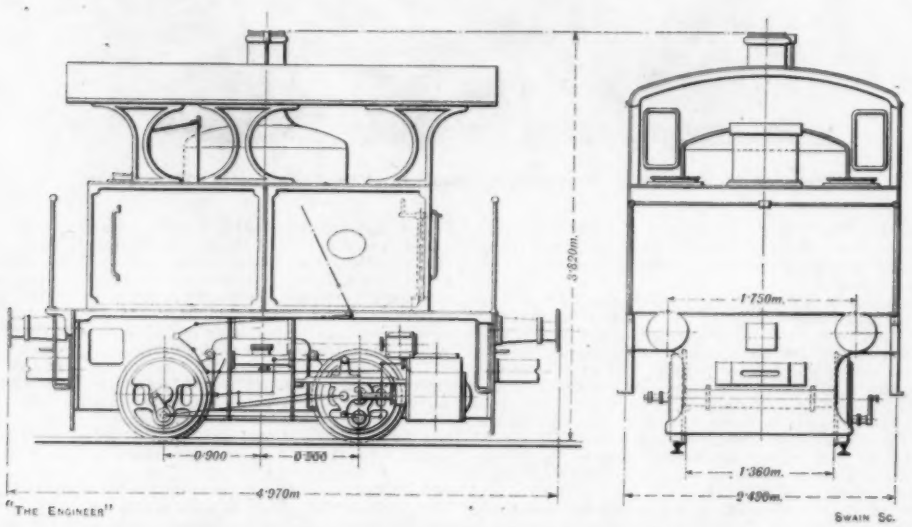
The weight of type V. locomotive empty is about 20 tons, and the boiler, when working, contains about 2500 lb. of water. The dimensions of the heavy pattern of type IV. are the same as those for the normal type, listed in the table, but the weight is somewhat greater, being about 19·5 tons in running order. The tractive effort at the drawbar is calculated by the formula—

$$F = \frac{K \times p \times l \times d^2}{D}$$

in which F = the tractive effort in kilogrammes,
p = the boiler pressure in kilogrammes per square centimetres,
l = the piston stroke in metres,
d = the cylinder diameter in centimetres,
D = the diameter of the driving wheels in metres,
and K = a coefficient, which varies from 0·5 to 0·65 according to the type and nature of the locomotive.

The tractive effort so calculated represents the pull the engine can maintain at the drawbar in steady work.

The boilers of these locomotives are of the Field water-tube type with great steaming capacity. Full working pressure can be raised from cold in about 45 minutes.



GENERAL ARRANGEMENT OF COCKERILL INDUSTRIAL LOCOMOTIVE

TABLE.—*Cockerill Locomotives with Vertical Boilers.*

Principal particulars.	Type III.	Type IV.	Type V.
Boiler pressure, lb.	140	170	200
Diameter of cylinders, inches	9·8	11·2	12·5
Stroke of pistons, inches	10·4	12·5	13·7
Wheel diameter, inches	24·2	27·5	31·4
Wheel base, inches	63·0	71·0	71·0
Boiler heating surface, sq. ft.	181·0	275·0	345·0
Grate area, sq. ft.	8·95	10·75	14·65
Capacity of water tanks, gals.	464	707	685
Capacity of coal bunkers, c. ft.	18·7	23·0	26·5
Length over buffers, feet	13·1	15·1	16·3
Overall width, feet	7·35	8·1	8·17
Overall height over rails, feet	9·3	10·5	12·5
Weight in running order (approximate), tons	12·8	17·7	25·0
Radius of sharpest curve taken, feet	34	51·0	51·0
Tractive effort at drawbar, lb.	2930	4920	8950
Load hauled on the level, tons	213	357	650

A feed pump driven from the engine normally maintains the water level, but a re-starting injector capable of supplying all the requirements of the boiler by itself so long as the feed temperature does not exceed 115 deg. Fah., is also fitted. The two safety valves are of Messrs. Cockerill's progressive discharge type. The locomotives are fitted with powerful hand brakes, and in the case of the larger sizes, and, if desired, of the smaller size also, an additional steam-actuated brake is provided, allowing of practically instantaneous stoppage in case of emergency. As will be seen from the illustrations, the cylinders are placed outside the framing, so that they and the Walschaerts valve gear are as easy of access as possible. The coal bunkers and water tanks are arranged at the side of the boiler, their weight being disposed with a view to the adhesion and the stability of the locomotive. One man only is required to work the engine. All operating levers and handles are situated conveniently for him. When at work he is protected from the weather by an adequate roof of sheet metal.

Locomotives of the type illustrated can have their sphere of usefulness extended by the addition of a windlass operated by a three-cylinder steam engine of the Brotherhood type. This is frequently very serviceable in stations, quarries, &c. It increases the weight of the locomotive by about a ton.

Electric Motor Starting and Protection.

(*Contributed.*)

THE quickening progress in the electrification of all kinds of industrial machinery is bringing an unfamiliar problem to be solved by managers and mechanical engineers who previously had no special knowledge of electric plant. The arrangement of the machines for production and the position and size of the electric motor are carefully planned as the result of experience, when new works or extensions become necessary, but the works engineer is sometimes at a loss in making a selection from the variety of appliances offered for connecting the motor to the mains.

Control gear, as the electrical engineer terms these appliances generally, has evolved from three elements. A switch to make and break the circuit, a fuse to serve as a weak link in the connections designed to melt on the occurrence of a short circuit, and a resistance to start up the motor gradually while limiting the starting current. The early forms of switches, fuses and starting resistances were dangerous to non-technical operators. Therefore the Home Office and other official departments issued regulations which stimulated the manufacture of the totally enclosed iron-cased gear that is invariably used at the present time.

Now, it is recognised that control gear has other functions to perform. If the supply fails, the circuit must be opened automatically or the fuses will blow or the motor burn out when the current is turned on again. The motor must also be protected against overloading as well as short circuits, or it may run overheated and eventually burn out, with consequent loss, because of the works production being stopped.

These considerations have led to the development of the automatic circuit breaker, which combines the functions of switch and fuse together with a no-volt release. A fuse cannot be wired closely enough to give overload protection, while the automatic release of the breaker can be adjusted exactly to the safe overload capacity of the motor. This quality of the breaker makes it possible for a motor of the most efficient size to be employed. Another advantage of the breaker, involving economy in maintenance cost and prevention of loss of output, owing to stoppages, is that the circuit can be closed again as soon as the fault is removed, while fuses take time to re-wire and cost money for renewals. A further convenience of the breaker is that it can be tripped from a distance by a small emergency switch, arranged at any desired point. The circuit breaker has superseded the switch and fuse, and on some supply systems it may eliminate the starter, thus reducing the control gear to one or two pieces.

The choice of control gear is complicated by the nature of the motor load, and the differences in the systems of power supplies. There are direct-current and alternating-current systems of various pressures and frequencies. For the ordinary direct-current motor driving shop shafting, or a machine, the choice of gear is restricted to a combination of a breaker and a starter with its resistance proportioned to pass a current about equal to the full load current when starting up the motor.

Squirrel-cage motors may be started:—

"*Straight-on.*"—Switching the motor directly on to the line by a circuit breaker fitted with a time lag device for the overload release.

"*Star-delta.*"—Switching the motor on to the line in two stages by a change-over switch breaker, which by a change of connections causes a lower voltage to be impressed on the motor windings at starting.

"*Auto-transformer.*"—Switching the motor on to the line in two stages by a change-over switch breaker in conjunction with a transformer which is arranged to be connected between the line and the motor in the first stage. The transformer steps down the pressure to start the motor, and when the motor has speeded up it is switched on to the mains and the transformer cut out of circuit.

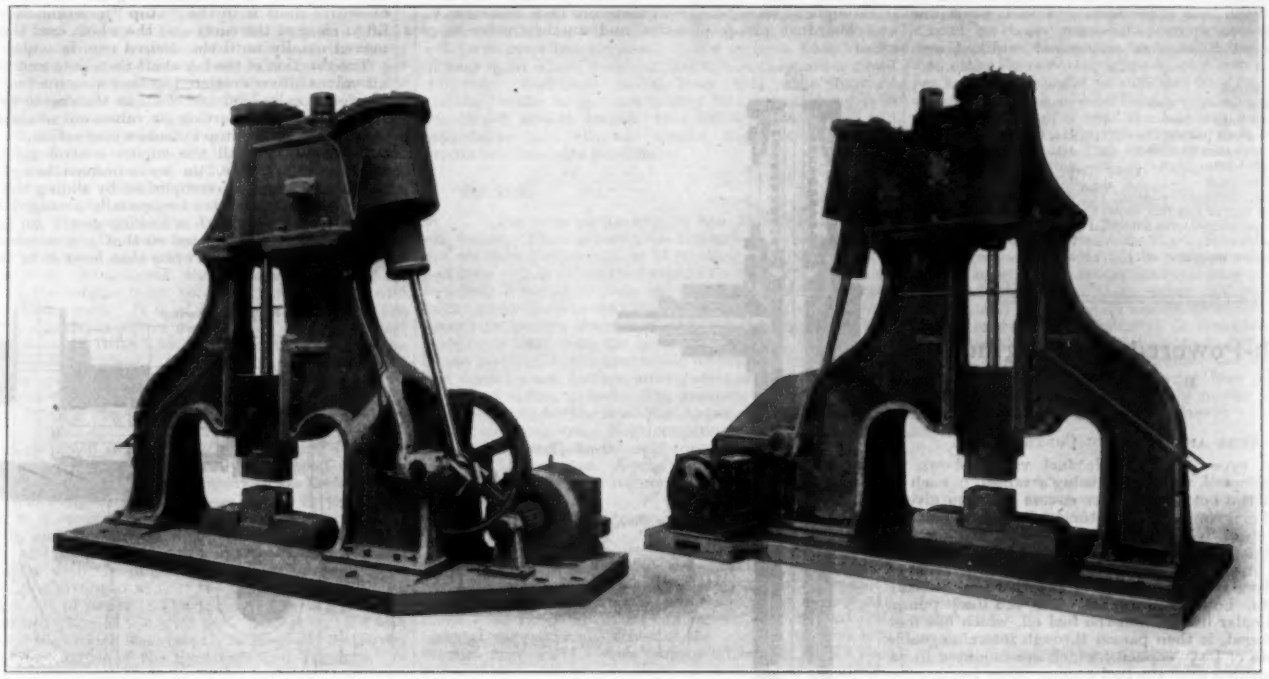
The usual method of controlling the slip-ring motor is with a circuit breaker for the stator circuit which is connected to the supply, and a graduated resistance connected to the rotor windings, and interlocked with the breaker to ensure the resistance being in circuit when the breaker is closed.

A starting device which combines a rotor resistance and stator switch with automatic releases is sometimes used for the slip-ring motor. But then it is necessary to have a circuit breaker installed near it to isolate the starter for maintenance inspection and because only one overload trip can be fitted to a two or three-phase motor starter.

Another complication for the man who is not often called upon to select suitable control gear is that the apparatus is made in two forms. There are air-break

30-CWT. ELECTRO-PNEUMATIC POWER HAMMER

B. AND S. MASSEY, LTD., OPENSHAW, MANCHESTER, ENGINEERS



circuit breakers with air-cooled starters and oil breakers with oil starters. Which form is decided upon depends on the intended position of the gear and convenience. Oil gear is undesirable in some places, and there are engineers who prefer not to have the necessity of making sure that the breaker or starter is always filled to the proper oil level; but oil gear is standardised and has proved satisfactory for all sizes of motors, while totally enclosed air breakers and starters are limited in size. Where there is neither prejudice nor technical reason for installing one or the other, cost is the deciding factor. A maker of repute will not recommend the use of unsuitable gear, and the customer should give full information of the source of supply and duty required of the gear to the manufacturer when making inquiries.

Out of this wide range of gear from which a selection can be made the occasional buyer wants some guidance in making his choice when he has to install new machinery or finds that old gear is giving trouble. The following suggestions may be of some aid. When a squirrel-cage alternating-current motor is driving on a loose pulley or directly on a fan or centrifugal pump, where the torque to start rotation is low, it can be switched straight on to the mains by means of a circuit breaker fitted with time lag devices on the overload releases. Motors up to 20 horse-power are started this way where there is no objection to the sudden rush of current which is momentarily taken from the line. Where the current peak at the moment of switching on must be reduced, the star-delta method is usual for a drive with a light starting torque.

The auto-transformer method is an alternative to the star-delta, and has an advantage over it in that connections can be made to tappings on the transformer, giving a range of three voltages less than the supply, for the first position of the starter, whereas only one definite per cent. of the supply is possible with the star-delta. This consideration is useful when a squirrel-cage motor is driving, say, a line of shop shafting with a number of belts which may stiffen up after a week-end standstill. If it be found that the motor will not always start on the lowest tap, the connections can be changed to the next higher.

Both star-delta and auto-transformer starters should contain no-volt and overload releases fitted with adjustable time lags or retarders to restrain their action at the moment of switching on.

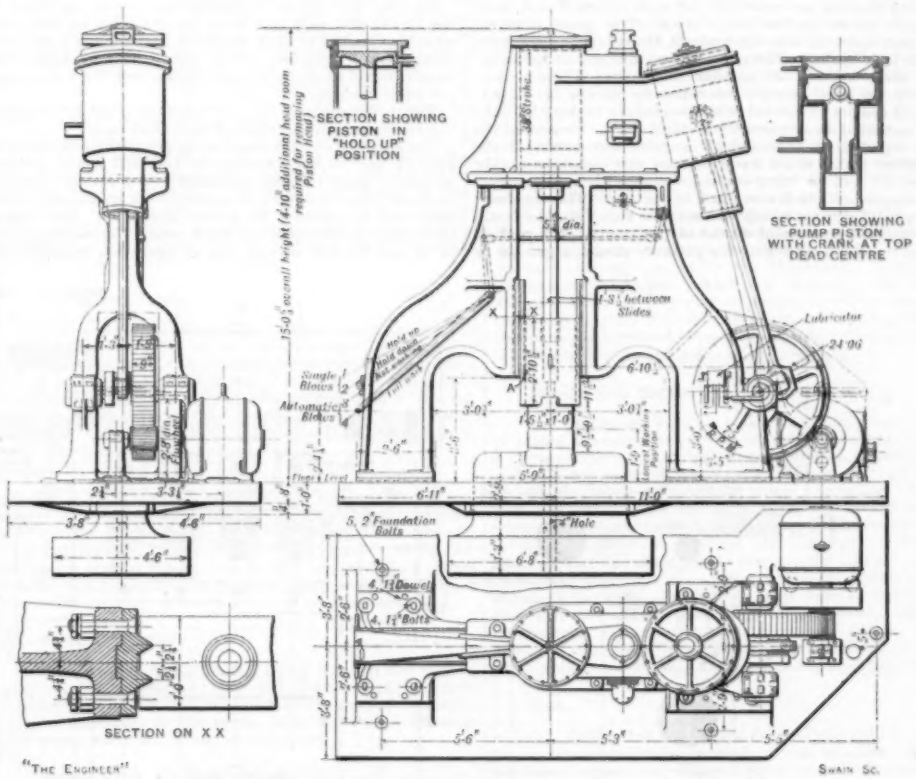
Some supply authorities will not permit the use of squirrel-cage motors on the line, except when the horse-power is quite small. Then the user has no choice but to install a breaker and starter to take care of a slip-ring motor. The breaker should be fitted with overload and no-volt releases, and the starter should be a simple piece of apparatus that would require no attention except an occasional overhaul and that can safely be operated by unskilled labour. Starters of this class can be made air cooled up to about 30 horse-power or oil cooled up to 1000 horse-power. These resistance starters limit the initial current by cutting out resistance step by step as the motor speeds up. They are intended for use at infrequent intervals, and are in circuit only for about 30 seconds. Their duty is to start any machinery which is set to work steadily at ordinary factory times.

Motors on cranes, lifts and machinery which is frequently started and stopped, are controlled by tramway type controllers with resistances calculated for the load. These are standardised for all supplies and duties, but do not often have to be considered by the man who has charge of a factory, mill or small works, and for whom these remarks on control gear are written.

THE announcement is made that Mr. G. V. O. Bulkeley, who has had a varied experience here—on the Great Western—and abroad, has been appointed to the new post of port manager at Killindini, Kenya Colony.

30-Cwt. Power Hammer.

HITHERTO there has been no difficulty in equipping smithies with electrically driven hammers up to 20 cwt. capacity, but for higher powers steam or compressed air has held its own. In order to overcome this limitation, B. and S. Massey, Ltd., Openshaw, have introduced an electrically-driven 30-cwt. hammer, which embodies the familiar features of this firm's power hammers of the overhanging type, with the arch form of frame. Views of the new hammer and a general arrangement drawing are given in the accompanying engravings, from which it will be observed that the hammer cylinder, pump cylinder and valve chest are in one and the same casting, which is securely bolted to the standards, the valve chest containing the controlling valve being provided with a renewable liner. The hammer cylinder is fitted with a stuffing-box, which is a steel stamping bolted to the cylinder. In this stuffing-box the packing is automatically tightened, when worn, by means of a spring, and the use of a loose gland, which requires constant adjustment, is obviated. The standards have adjustable slides of forged steel, provided with double V's, and are accurately machined to fit the cylinder and base-plate. One of the standards is bifurcated, and is fitted with bearings to carry a mild steel crank shaft, on which is secured a machined spur wheel that meshes with a Fabroil pinion on the motor shaft, which carries a fly-wheel. A long forged steel connecting-rod operated by the crank shaft drives the air pump, the piston of which is of the trunk pattern with two sets of rings. The main piston and rod are in one piece, of forged steel, machined all over, and the piston has steel rings of the Ramsbottom type. The anvil block is an iron casting with a large base, separate from the base plate, and including the pallett weighs about 12 tons. The tup pallett and anvil pallett are of tough steel, with planed hardened faces, the dovetails being machined to fit the tup and anvil block to which the palletts are secured by steel keys. The tup is a mild steel forging machined to fit the slides, dovetailed to receive the tup pallett, and bored to take the tapered end of the piston-rod.



ARRANGEMENT OF ELECTRICALLY-DRIVEN PNEUMATIC HAMMER

The control enables light or heavy automatic blows to be given at the speed of 75 per minute, or single blows to be administered of any force and length of stroke at any instant by a simple movement of the hand lever shown. The single blows are obtained by the admission of air under pressure from a reservoir incorporated in the cylinder casting into the cylinder, without the need of a timing device. By means of the same mechanism the hammer will "hold up" at the top of the stroke, or will "hold down" so that work can be gripped between the palletts.

The gearing is all enclosed and an automatic system of lubrication gives a positive supply of oil to the pump and hammer cylinders and to the big end of the connecting-rod. The small end is lubricated by a floating gudgeon pin arrangement. It will be observed that there is ample room for the hammermen round the anvil block, and work can be dealt with both at the front and back, while cranes can be swung close up to the hammer.

The principal dimensions and power required are as follows:—

Longest stroke	39in.
Clear space between slides	20½in.
Size of tup pallett face	17½in. by 12in.
Height of anvil pallett face	1ft. 9in.
Anvil pallett face to slides	1ft. 9in.
Total height from floor	15ft. 1in.
Size of baseplate	17ft. 11in. by 8ft. 2in.
Motor size, continuous rating	50 B.H.P.
Maximum power (on full blows)	75 B.H.P.
Average consumption in a normal smithy	9·4 kilowatt-hours/hour
Approximate weight	37 tons

High-Powered Oil Engines.*

By W. S. BURN.

(*Concluded from page* 496.)

Fuel and Starting Controls.

A simple type of automatic fuel valve—shown in Fig. 10—is adopted, two valves being arranged in each of the top and the bottom cylinder covers so as to give a symmetrical and similar distribution of fuel in both of the combustion spaces. With such a valve the fuel timing and the rate of the fuel injection are entirely controlled by the fuel pump. A vital factor affecting the good operation of the fuel valves is the provision of effective fuel filtering arrangements, both before and after the fuel pump. In this particular installation the fuel oil, which has first been centrifuged, is then passed through interchangeable suction filters of large capacity which are mounted in an accessible position over the fuel pump. After leaving the fuel pump delivery valves and just previous to entering the two fuel valves the oil passes through a small high-pressure filter, one filter being provided for each pair of fuel valves.

A drawing of the fuel pump is reproduced in Fig. 11. It will be seen that the plungers are cam-operated, and the characteristics of the pump are therefore largely dependent on the shape and the lift of the cam. The oil pressure as generated by the pump is necessarily intermittent, the normal maximum pressure in the pump body being 6000 lb. per square inch, while the normal minimum pressure in the system is about 100 lb. per square inch. The latter range of pressure is generated in a period of about 36 deg. of crank angle occupying at the normal engine speed of 90 revolutions per minute one-fifteenth of a second.

A separate and independent pump and the gear appertaining thereto are provided for each cylinder end, each plunger operating two fuel valves. The pump plungers are cam-operated through rockers, the return stroke being made by a spring. The rockers are mounted on an excentric shaft capable of angular movement. The suction valves are mechanically operated by means of tappets on bell cranks connected with the plunger rockers by links and mounted on an excentric control shaft. Control of the fuel injection is obtained by angular movement of the excentric rocker shaft, a control cam on which operates the excentric suction valve control shaft and lowers or raises the tappet bell crank according to the load. This regulates the period during which the suction valve is closed and so regulates the useful stroke of the pump; the suction valve being closed during the pressure stroke, a greater or less amount of oil is delivered depending on the position of the excentric control shaft.

The governor is arranged to control independently the suction valve control shaft. Regulation of the output of any pump plunger can be made separately by the adjustment of the suction valve tappet screw. The pump gear is such that the suction valve is open, except for the period of injection and hence the system is relieved of pressure except during the injection period; the leakage throughout the system will therefore be a minimum.

The fuel pump plungers and suction valve tappets

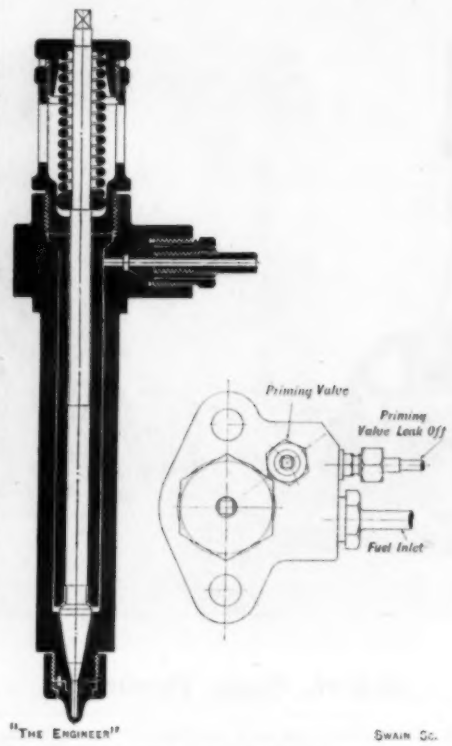


FIG. 10—FUEL VALVE

operate in glandless cast iron ground bushes and are designed with ample guides so that all side loads are eliminated from the actual plunger. The pump body is of forged steel and is attached to the bed-plate by cast iron brackets which also support the cam and control shafts.

Starting Air Valves.—Starting air valves are fitted to the top covers only and they are arranged in the corresponding pocket to that which is used for the piston-rod in the lower cylinder. They are of slightly larger size than is usual in single-acting engines and the valve cages are water cooled.

The starting air master valves consist of balanced poppet valves working in a common forged steel body.

The starting air valve operating gear, which is shown in Fig. 12 and is very similar to the fuel pump plunger operating gear, consists essentially of a rocker mounted on an excentric shaft which is capable of an angular movement and is operated by a cam and roller. An angular movement of the excentric shaft causes the starting valve to be put quickly into or out of operation in either the ahead or the astern direction. The rockers, it may be noted, are identical with the fuel pump rockers.

To start the engine, starting air is admitted to the top cylinders whilst fuel is admitted to the lower cylinder towards the end of the starting period, the initial firing therefore taking place in the lower cylinder. In this manner very ready starting should be obtained, as no cold starting air is introduced to the cylinders which are firing first.

Separate ahead and astern cams are provided for both the fuel pump and the starting air valves. When the excentric shaft is in the "stop" position the rollers are lifted clear of the cams and the whole cam shaft may be moved axially until the desired cam is under the roller.

The rotation of the lay shaft then puts first the starting air valves into operation, together with the fuel pumps for the lower cylinders, and then, as the engine fires, further rotation puts the starting air valves out of action and the fuel pumps for the top cylinders into action.

Control Gear.—All the engine control gear is of the hand-operated type, no servo-motors being employed.

The reversing is accomplished by sliding the cam shaft laterally by means of a horizontally arranged hand lever which is provided with a locking gear. An interlocking arrangement is also fitted so that any movement of the reversing lever, except when that lever is in the "stop" position, is prevented. The starting of the engine and the control of its load and speed are all carried out by the rotation of a large hand wheel at the control station, which is provided with a central attachment for locking it in any desired position. The governor is of the vertical Hartung type, and is driven by bevel wheels from the main fuel pump shaft. These bevel wheels are the only bevel wheels on the engine, the main drive from the crank shaft to the fuel pump and control unit being obtained by a double connecting-rod which runs in a closed oil-tight casing fitted at the forward end of the engine bed-plate. This drive is silent and very effective. For convenience, the tachometer, the speed counter, and the recorder for

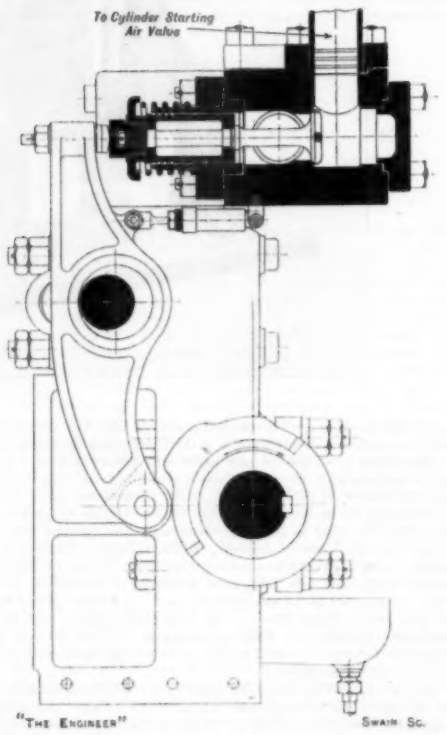


FIG. 12—STARTING-AIR VALVE OPERATING GEAR

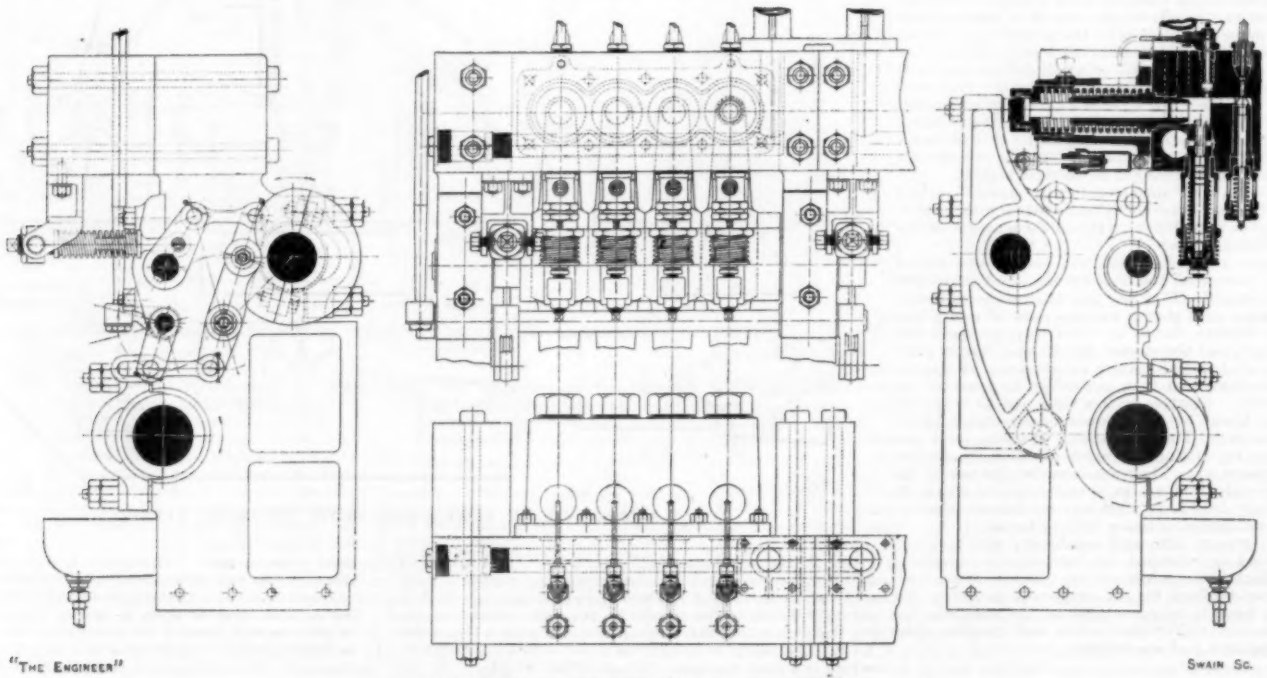


FIG. 11—GENERAL ARRANGEMENT OF FUEL PUMP

* North-East Coast Institution of Engineers and Shipbuilders.—Abridged.

indicating the direction of rotation of the engine are mounted in one instrument and are driven from an extension of the governor spindle.

At the forward end of the control unit is fitted a gauge board with gauges for the air, fuel, lubricating oil and cooling water, so that the dials are in full sight of the attendant standing at the control wheel.

Testing Plant Arrangements.—For the purpose of testing the single-cylinder experimental unit a turbo-blower with a designed output of about 4000 cubic feet of air per minute served as a scavenge pump. The blower is of the Reavell type and is fitted with diffuser nozzle control embodying the maker's latest practice. It is directly coupled to a Laurence Scott high-speed direct-current motor designed for a maximum output of 55 brake horse-power when taking 240 amps. at 200 volts and running at a normal speed of 3940 revolutions per minute. The motor is designed for a range of speed variation from the maximum of 3940 revolutions to a minimum of about 2800 revolutions. Under normal full-load testing conditions an average of about 45 brake horse-power is taken with current of 150 ampères, the average scavenging air pressure in the engine main being between 1·75 lb. and 2 lb. per square inch. It is of interest to note that the scavenging apparatus above described is one of the first examples of an all-British machine, and in operation the blower is noticeably silent. In order to measure the quantity of scavenging air both a calibrated nozzle and a curved tube manometer supplied by George Kent and Co., Ltd., and reading directly in cubic feet per minute, are employed.

The fuel oil which so far has been used during the trials is an ordinary Anglo-Persian fuel oil with a specific gravity of about 0·895. For the measurement of the brake horse-power a water dynamometer is employed in the usual manner; it is coupled by a short length of shaft placed between it and the engine fly-wheel. The fly-wheel is closed in and is provided with external barring teeth which engage with the pinion of an electrically operated turning engine arranged so that the pinion can quickly be put in and out of action. The thrust block is built into the engine bed-plate at the after end. The remaining test apparatus is that which was recently successfully employed in testing the engines of the Sycamore and Tramore. It comprises a lever weighing machine for the direct measurement of the amount of fuel oil used and a cooling water service. Means are provided for assessing the amount of cooling water used in the various cooling circuits through the medium of orifice tanks. Arrangements are also to hand for warming up the cooling water by steam, so that a relatively high cylinder jacket temperature can be rapidly obtained when starting up the engine.

Some Trial Results.—So far the test made have consisted principally of preliminary runs and tuning-up tests of short periods, say, up to six hours. It may be of interest to state that the engine started up nearly three weeks ago entirely without incident. Prior to running up, the fuel settings were checked by arranging the fuel valves so that a single orifice in the spraying nozzle projected a fine stream of fuel on to a marked portion of the fly-wheel face at the top centre position. The fuel sprays were shown to be finely diffused and accurate in their setting, and when closed up the engine started straight away and no difficulty has been encountered in any of the numerous starts since made.

When the present series of short trials are completed it is hoped to begin a long non-stop reliability trial which may extend over several weeks.

After this trial has been made it is hoped to publish extended trial results and a full analysis of the engine performance.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Improved Situation.

THIS week has seen a rapid improvement in the industrial situation in the Midlands and Staffordshire, but, owing to the dislocation which ensued as a result of the labour crisis, it must of necessity be some time before normal conditions can be reached, and the whole of the workers in the iron and steel and engineering works can be re-absorbed. For about ten days no manufactured goods left the works, and little or no raw material went in. In addition, coal stocks have been depleted, and firms are doing what they can to conserve fuel for vital work. Nevertheless many works have resumed operations, though in some cases they are not working anything like full time, and employers generally are doing their utmost to facilitate the return of their employees. The heavy industries are greatly handicapped by the shortage of fuel supplies, and furnaces and mills now in operation will shortly come to a stand unless the miners return to work and that with a will. We have had so much trouble from this source in recent years that it is of the utmost importance to the industrial life of the nation that an abiding settlement in the coalfields should be reached. Every other trade which has been involved in the recent upheaval is evolving, or has already agreed upon terms calculated to insure peace for some time to come. It is the duty of all parties in the coal dispute to strain every effort to do likewise.

Market Position.

This week has been an extremely poor one as far as the buying and selling of iron and steel is concerned. The calling off of the general strike has afforded a certain amount of sentimental relief, but the practical effect so far is not in sight. Buyers take the view that it is useless to negotiate in face of the inability of the iron and steel trade to supply material. Nominal prices are unchanged, though there is insufficient business to apply any practical test. Though material is still being turned out in the Midlands, several blast-furnaces which were blowing a fortnight ago are now damped down. Many forges likewise are out of action, while there is very little activity in the foundries. Probably a larger proportion of mills is in operation in the Black Country, relatively to the total general plant, than in any other district. The tube trade has not been brought to a standstill, and some of the local strip makers have resources which enable them to offer supplies for a month or two to come. Producers of iron and steel are directly dependent upon raw fuel, and until there is a settlement in the coalfields, ironmasters will be more or less helpless. A few of them have stocks of coal upon which they can draw, but they are a small minority. Sufficient orders have this week reached Midland works to indicate a very fair demand, and it is considered almost certain that other negotiations will materialise into business almost immediately normal production becomes possible.

Pig Iron.

Pig iron production in the Midlands is almost suspended. There is very little fuel to be had, and furnaces did not take the precaution of stocking heavily. Demand had been so thin of late that smelters considered they would lose little if forced to close down; indeed, a little business might accumulate in the interim. Everything now depends upon how quickly the miners can be got to work, for it is considered that, with the labour cloud lifted, freer buying of raw material in the immediate future is to be looked for, and smelters are further anticipating some improvement on recent selling values. The business put through this week has been for the most part for small parcels to enable works to carry on. Northamptonshire No. 3 foundry iron stands at £3 2s. 6d. and forge at £2 15s. to £2 16s. per ton at furnaces. Derbyshire foundry ranges from £3 6s. 6d. to £3 7s. 6d., and forge from £3 to £3 1s.

Staffordshire Bar Iron.

The Staffordshire bar iron industry continues in its enfeebled state. Makers of marked iron have a certain amount of work on hand, and further business in prospect, but producers of merchant and common qualities can make little headway in face of severe internal and continental competition. Whereas the marked bar standard remains firm at £14, Crown bars vary from £11 to £11 10s., and nut and bolt quality bars sell at from £10 to £10 5s. Most of the mills in operation are engaged re-rolling steel, and in this line are competing very successfully with the large steel works. Wrought iron gas-tube strip is in moderate request at £12 5s. to £12 10s. The tube works are among the best employed establishments in this district at the moment. Continental No. 3 iron for nut and bolt and fencing requirements continues to come through on old contracts. Little fresh business has been given out to Belgium of late, there having been increasing complaints of unsatisfactory quality.

Steel Business.

Inquiries have been circulating this week pretty freely for considerable quantities of structural steel. It is, of course, recognised that steel masters cannot as yet give delivery, but engineers wish to probe the market so that as soon as the Whitsun holidays are over they can get to work on the business in hand, and be ready for the large amount of new work which is known to be pending, and which it is thought will now be proceeded with. Sellers generally held to the Association figures of £7 2s. 6d. for angles and joists, and £7 17s. 6d. for ship, bridge and tank plates. Boiler-plates were quoted £11 to £11 10s., and small rolled bars £7 15s. to £8. Most sellers of mild steel billets wanted £6 2s. 6d., but it was reported that for a good tonnage that figure would be shaded by some of the large steel works. Engineers on 'Change in Birmingham to-day were more optimistic as to the future than they have been for many months past, and once the wheels of industry get properly moving again, "full speed ahead" is expected to be the order.

Galvanised Sheets.

Galvanised sheet mills have in many cases a fair reserve of orders, and though new business is not coming forward very freely, it is anticipated that next week should see a stir in the home demand. Shipments have been held up, but transport is gradually getting back to normal, and a considerable tonnage should find its way to South America. Values of 24-gauge corrugated sheets range from £15 5s. to £15 15s. f.o.b. Liverpool.

Steel Scrap.

There were fair quantities of steel scrap on offer on 'Change to-day, and quite an appreciable amount changed hands. Merchants generally quoted £3 7s. 6d. delivered South Wales, and would not entertain offers made by consumers who in some cases maintained their pre-strike attitude of lower prices or no business.

Foreign Material.

Practically nothing is being done in the way of buying foreign material. One reason is that the Continent has not much to sell, but the main explanation is the anticipated congestion at the ports, and the serious obstacle still anticipated in the way of transport.

Reorganising the Steel Industry.

Considerable attention has been aroused in Midland industrial circles by a striking speech on the subject of the reorganisation of the steel industry of this country made by Mr. W. L. Hichens, chairman of Cammell Laird and Co., in Birmingham just previous to the strike. He began by saying that the fundamental reason of the depression in such industries as coal, steel and shipbuilding, was that there were too many businesses in existence for the demand, and that if by some disaster half the number of steel furnaces in this country were suddenly put out of action, he would prophesy a boom in the steel industry to-morrow. He submitted that it was no good hanging on, especially in the steel industry, because by the time prosperity came, assuming that it did, it would probably be found that the plants that were redundant to-day would be obsolete then. If it were admitted that there were too many steel firms in existence at present, he submitted for their consideration a scheme—the only possible one he thought they could adopt with success at the present time—for eliminating redundant works. Might it not be worth while, he said, for the members of the steel industry to get together and agree that there was an excess of, say, 25 per cent.? Might they not then say:—"We will appoint some independent body whose business it should be, bearing in mind economic and geographical considerations, to determine which firms are to close down." The other firms would agree to pay into a pool so much per ton, which should be sufficient to give a moderate rate of interest, and a sinking fund to the firm that was closed down; and in order that the addition per ton should be more moderate, it might be suggested that a corresponding duty should be placed on all foreign steel coming into this country. In this way they would preserve competition, they would not in any sense be reducing employment because, *ex hypothesi*, there would be as much work as before—what two firms did would be done by one—and they would get such economies from having comparatively full shops that it would not be necessary to raise the price per ton to pay the contribution into the pool. Mr. Hichens admitted that there were many difficulties about the scheme, and that it would almost certainly require legislation to carry it into effect, but he considered it would be far preferable to the establishment of a big combine to buy up all the steel plants and eliminate the redundant, or to achieving the object by allowing the forces of competition to do their work ending in the survival of the fittest.

Obituary.

In commercial circles in the Midlands and on Birmingham Exchange few men were better known or more highly respected than the late Mr. Edwin James Hunt, of Bescot, near Walsall, whose death on Sunday last I have to record. Another familiar figure in the industrial life of South Staffordshire which has been removed by death is that of Mr. Henry Watson Smith, of the firm of Eliza Pinsley and Sons, chain and nail manufacturers, of Old Hill.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THERE has been a more or less general resumption of work this week in the Lancashire area following the strike, but conditions are a long way from normal, and are likely to be for some weeks. In the case of the London, Midland and Scottish locomotive works at Crewe, for example, only 5000 of the 10,000 men who are employed by the company were started on Monday, when a portion of the works was opened, and then only for four days a week. A movement was started for the cancellation of the Whitsuntide holidays in Manchester and district, the object being to make up to that extent for the time irrevocably lost through the general strike. As, for all practical purposes, the greater part of White-week is dead from a trade and industrial point of view, there was something to be said for the idea, but the suggestion has been rejected mainly on the grounds that it was made too late to enable alterations in the customary procedure to be made. Friday and Saturday of Whit-week are two of the eight days which, in accordance with an agreement between the Manchester and District Engineering Employers' Association and the unions concerned in the engineering trades, are observed as definite holidays, and the opinion is expressed by the Association that the various firms which it represents will observe the same rules as in previous years. A useful contract is being placed by the Manchester Corporation Tramways Committee which, on Tuesday, decided to accept tenders for fifty new tramcars, the firms concerned being the English Electric Company, the General Electric Company, the British Thomson-Houston Company, and the Brush Electrical Engineering Company.

Non-Ferrous Metals.

In the markets for non-ferrous metals instability of values has continued to characterise the tin and copper sections. The demand for tin has been on a small scale, and values have steadily given way, the tone at the moment of writing being particularly weak. In some quarters here one meets with the view that a recovery will be witnessed before long, but even given a continuance of a favourable statistical position, the demand will have to pick up very considerably to move values in an upward direction. There has been some buying of copper, but not sufficient in the aggregate to keep values steady, and although the fluctuations are not severe the tone seems to be decidedly on the weak side. Lead and spelter, as has been the case recently, seem to keep up fairly well, and in both cases a moderate inquiry is being experienced.

Iron.

In the iron and steel markets the key to the situation is undoubtedly the question of coal supplies. Most of the blast-furnaces are damped down, and the general view is that no attempt will be made to resume the production of iron until the coal problem is definitely settled and steady supplies of fuel are assured. Under the recent prevailing conditions, it was to be expected that orders for pig iron would be held up, even if transport facilities were such as to ensure deliveries. As a consequence there has been a fair amount of inquiry for pig iron during the last few days and stocks at furnaces are certainly much less than are needed to meet orders in hand. There has been a quiet feeling on 'Change here during the past week or two that an advance in quotations would be made, and that has been borne out this week. On Tuesday, Derbyshire No. 3 quality was increased to £3 17s. 6d. per ton, delivered Manchester or equal distance, or an advance of about half-a-crown a ton compared with the prices lately ruling here. In view of a similar increase in Cleveland pig iron on the Middlesbrough market the previous day, this move was not altogether unexpected. In the case of other makes

the position is rather obscure. Sellers in some instances have withdrawn quotations, but there is no doubt that higher rates may be looked for. Bar iron makers restarted this week, but stocks of fuel are low and only about sufficient to enable them to continue until the week-end. In the meantime the demand is slow, and prices are without change at £11 per ton delivered for Crown bars and £9 15s. per ton for second quality material.

Steel.

Generally speaking, most of the plate and section mills remain closed, and, as is the case at the blast-furnaces, are not likely to restart until supplies of coal are available, although some of the re-rolling mills resumed operations at the beginning of the week. In the latter case, however, it is expected that an early stoppage will be unavoidable unless the coal dispute is settled. Some of the steel firms are favourably situated from the point of view of orders, when a resumption is possible, and it is expected that further contracts will be placed when steel makers are in a position to gauge with some degree of certainty their production costs over future months. On this market prices remain without change at £7 2s. 6d. per ton for joists and sections, £7 17s. 6d. for ship plates, and £8 to £8 5s. per ton, delivered Manchester, for steel bars. Galvanised sheets continue to display a rather steadier tone, and some small export orders have been booked at £15 10s. to £15 15s. per ton f.o.b., although the bulk of the inquiries from the Indian market are below this range. Continental offers of steel are at more or less nominal prices, in view of the absence of any serious business. Ordinary plates are at about £6 6s. per ton, Siemens plates at £6 10s., joists at £5 12s. 6d. to £5 15s., sections at £6 2s. 6d., and sheet bars at about £5 2s. per ton delivered Manchester, for cash against documents.

Scrap.

The demand for iron and steel and non-ferrous metal scrap is quiet. Textile machinery scrap is quoted at about £3 10s. per ton, ordinary machinery cast iron scrap at £3 5s., mild steel at £2 12s. 6d., and wrought iron at £3 5s. on truck, Manchester. Cast aluminium scrap is offered at about £88 per ton, zinc at £24, lead at £26 to £27, braziery copper at £49, heavy copper scrap at £60, and heavy yellow brass at £45, these prices being for graded qualities delivered to users' works.

The Engineering Industry.

Although it will be some time before normal conditions prevail again in this great industrial area, there was a general resumption of work immediately the strike was called off. A few hitches here and there were, of course, inevitable, and were largely due to the dissemination of false reports with regard to the conditions on which railwaymen were to be taken back. On all hands it was reported that the members of the engineering unions were by no means unanimously in favour of the general strike, and in many shops the workpeople did not come out at all, while in other shops work was only discontinued purely on account of lack of materials or failure of means of transport. One of the most remarkable features of the whole affair perhaps was the almost complete absence of ill-feeling. Another outstanding feature was the wonderful response to the call for volunteers to carry on the essential public services and particularly the railways. Volunteer drivers and firemen for locomotives were at work within twenty-four hours of the rupture, and the transport by road of foodstuffs was carried on efficiently. Some interesting experiences are reported by amateur locomotive drivers, such, for instance, as the dropping of plugs due to shortage of water, but serious accidents were noteworthy only by their absence, and it is certain that had the strike lasted a few days longer the railway services would have been greatly extended. The electric train service between Manchester and Bury on the London, Midland and Scottish line was operated entirely by volunteer engineers. There was fortunately no trouble at the local electric power stations, which are staffed by members of the E.T.U., who did not join in the general strike. Although therefore the actual stoppage of work in the engineering shops was of very short duration, it must be some time before business can be conducted normally, and it is very unfortunate that the Whitsuntide holiday season is at hand. There is no other district which indulges in such a long holiday at this time of the year. Looking back on this most unfortunate business, one cannot suppress the feeling so frequently expressed in these parts that the strike simply had to be, and that nothing else could clear the industrial atmosphere so effectively. Now that both sides have shaken hands and a clearer understanding has been arrived at between all sections engaged in industry, a greater feeling of confidence is likely to be established and a general improvement in trade may be reasonably anticipated.

BARROW-IN-FURNESS.

A Survey.

As far as the iron and steel trade was concerned, the general strike put a stop to practically all activities. There was one exception, the Hodbarrow Mining Company, which continued to work throughout the whole period. Of course, its present output has been restricted in view of the general state of the trade throughout the district. Although the streets were crowded with strikers, there was never during the whole period one single act of violence. Transport workers were never interfered with, and those who remained at work were not molested in any way. This fact can be read in two ways. One that the men were determined to keep the peace, and the other that the men were not heart and soul with the action. It may be safely concluded that the latter contributed largely to the quietness. That is, at any rate, the opinion of people who were in a position to judge. The men had obeyed the call to come out, but were by no means sure that it was the right thing. And now, after the *debâcle*, the leaders are being subjected to severe criticism. At Vickers' large works the coal strike had not affected any department, and all the departments were in full work until the engineers came out, which they did with very bad grace indeed, and immediately the strike was over they were eager to get back. All departments are at full power as regards labour, and as the firm holds a large store of coal, the strike is not likely to affect it for a long period yet. So soon as the strike was called off, the hoop and small section mills at Barrow made preparations for restarting, and they are now running as usual, but there can be no question of the iron and steel departments restarting until the coal troubles are settled. When that takes place there should be a better chance of trade improving than there has been for some time. For a considerable period the outlook has been blurred by clouds on the horizon, but as soon as the report is "Visibility good," then the North-West district should experience better business than it has for some time.

SHEFFIELD.

(From our own Correspondent.)

Effects of the General Strike.

THE general strike threw the steel trade of Sheffield and district into a chaotic state for a fortnight, bringing the heavy departments almost to a standstill, and also affecting the lighter side to a considerable extent. Now that the strike is over, the position is naturally a good deal better, but it is still far from normal, owing to the coal stoppage. The firms possessing big installations of melting furnaces consume enormous quantities of coal, and, as they have no facilities for stocking large supplies, they are dependent on regular deliveries, which deliveries, of course, are not being received now. The local Coal Emergency Officer is unable to help them. At the end of last week he announced that in view of the uncertainty of the position no permits for industrial coal would be issued until after Whitsuntide, and that, unless the situation improved, it was extremely doubtful whether it would be possible to authorise further supplies to any manufacturers. The consequence of this is that the heavy side of the steel industry finds itself in a very unfortunate position. The big open-hearth plants were closed down immediately the general strike commenced, and there has been little or no resumption yet. The majority will probably remain closed until after Whitsuntide. The same handicap has prevented anything like a full return to work in the heavy manufacturing departments, which produce railway axles and tires, and marine forgings.

The Lighter Trades.

The industries which require smaller supplies of coal, or which are able to carry on with gas or electricity, have made a better recovery from the general strike. The production of crucible steel and various special steels is being maintained to a fair extent. On the engineering side the position is satisfactory, and some of the largest firms have been able to return to practically pre-strike conditions. The Sheffield electricity department supplies a great deal of industrial power, and many smaller firms, as well as departments of the larger concerns, depend very largely upon that source. The department is in a position to give full supplies. At the beginning of the strike, it had on hand a stock of coal sufficient for eight weeks, and something like seven-eighths of that quantity remained when the strike ended. Gas also is used on a considerable scale for power production, and here again the position is quite satisfactory. The cutlery and plate trades have not been greatly affected by the strike. The employees came out at first, but they did so under a misapprehension, and were soon back again. Transport difficulties impeded the work considerably, however, and some hundreds of employees were thrown out of work as the result of the strike.

Increased Production of Steel.

There is still a feeling that brighter times are in store for the steel trade, providing labour peace can be established, and this optimistic view is supported by recent increases in production. The output of the Sheffield area during March was 108,200 tons, which was the highest figure for several years. It was 7000 tons up as compared with February, and 12,000 tons more than March of last year. The total included 57,000 tons of basic steel, and 41,800 tons of acid, as well as 7000 tons of castings and other descriptions of steel. Lincolnshire also showed an increase, its total production being 42,500 tons, as against 34,000 tons in February and 33,100 tons in March last year. There was also an increase in the output of Lincolnshire pig iron to the extent of about 10,000 tons.

A Better Outlook.

It is not to be supposed that many orders were placed during the strike, but it is understood that there are many waiting to be given out from various parts of the world, as soon as normal times are resumed. The two great requirements are cheaper fuel and cheaper transport. The lighter trades especially view the future with confidence. One leading manufacturer has expressed a very optimistic opinion. "As soon as the men get back to work," he said, "and things have assumed their normal condition, we shall have one of the biggest revivals in trade, and enjoy one of the most prosperous periods that Sheffield has ever experienced in the whole of her history."

Lincolnshire Ironmasters' Notice.

In a notice posted at the various works at Scunthorpe and Frodingham, the Lincolnshire Ironmasters' Association says:—"The members of the Association wish to make a strong protest against the cessation of work without the specified notices being given, in breach of the agreement which has been honourably observed by all parties for many years. They, however, appreciate the friendly personal relations which have so long existed. The members deeply regret the long and continued depression in the iron and steel industries which has rendered impossible the maintenance of normal employment. They will make every effort to secure the earliest possible resumption of work on the conditions in operation before the stoppage, looking forward with confidence to the maintenance of a mutual consideration and cordial co-operation which are essential to the restoration of the prosperity of the industry which is so vital to all in any capacity who are dependent upon it."

New Gasholder for Chesterfield.

In consequence of the increased demand for gas at Chesterfield, the Town Council has decided to erect a new gasholder, and has accepted a tender of £46,000 for the work. It was stated that the cost would not fall on the rates, but would come out of the profits of the undertaking.

Safety Razors for Soldiers.

The conservative attitude which prevails in Government departments has for some time been illustrated in two instances relating to Sheffield manufactures. Although stainless steel table cutlery was introduced several years ago, and has become widely popular, the authorities of the Army and Navy have consistently specified the older kind until this year, but now, at length, the Admiralty has adopted stainless for use of the officers of the Navy. Safety razors have been in regular use for an even longer period than stainless knives, but still only razors of the old straight type have been served out to the troops. A recent question in the House of Commons, however, brought the reply that the Army authorities have under consideration the adoption of safety razors, and that a decision may be expected at an early date.

Hadfields' Works Facilities.

Some interesting facts regarding the facilities at the works of Hadfields, Ltd., were given by Sir Robert Hadfield at the recently held annual general meeting of the company. He had seen, remarked Sir Robert, in a daily newspaper, a statement, in connection with the Trade Union Mission to the United States, which returned not long ago to this country, that, at the elbow, so to speak, of every workman in the United States was placed 1½ horse-power; that was that, in addition to his human energy, much use was made by him of "machinery energy." As the point appeared to be of interest, Sir Robert had an analysis of the power available and used in their own works, including electric, steam and hydraulic power. As a result it appeared that of actual manufacturing machinery, exclusive of rolling mills and presses, there were 4½ horse-power per man. For transport and lifting appliances there were 2·3 horse-power per man, so that excluding rolling mills and presses, there were no fewer than 6·8 horse-power "at the elbow" of each man in the East Hecla and Hecla Works, as compared with the 1½ horse-power at the disposal of the American workman. If the power employed in the rolling mills and presses were taken into account, there were no less than 12·4 horse-power per man in the Sheffield works. It would thus be seen, continued Sir Robert, that the worker at Hadfields was not short of power, and that the works compared most favourably with the latest and best American works.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Strike and its Effects.

THE general labour upheaval struck a very severe blow at the great iron and steel industries in the North of England, and under it they will be staggering for many months to come. Within twenty-four hours of the "cease work" ultimatum of the Trades Union Congress all the iron and steel works in this district were at a complete standstill. The blast-furnaces, with the exception of two, were damped down immediately, and about half a dozen have since been allowed to die out altogether, and they are not likely to be restarted until they have been relined and repairs executed. So far as the remainder of the furnaces are concerned, they will, of course, remain inactive until constant and adequate supplies of fuel are forthcoming. A few small foundries have been able to continue operations without interruption, but their activities are now threatened owing to the cutting off of fuel supplies. For some considerable time past—ever since the 1921 coal strike, in fact—the iron and steel trades have had to face innumerable difficulties, including fierce competition from America and continental countries, but the recent blow is the biggest of all. The foreigner has been able to step in again and capture many, if not all, the markets which were, before, essentially British. As a result of the lightning strike, the British workers have thus played into the hands of the foreigner. Markets have been lost in the past through strikes, and more will be lost through this upheaval. The foreigner steps in and the wages which should have gone into the British workers' pockets will be spent by overseas workmen. The struggle for existence, in a commercial sense, was keen enough before this strife came and made it even more difficult for manufacturers to make a real fight of it. There is a still further tragic sequel, for the blow came just at a period when there was a glimmer of a steady trade improvement, and not for some considerable time past had so much optimism prevailed in the staple industries than just before the cessation of work. The North of England has so far been able to weather the storm of a long depression, and was hopeful of having at least turned the corner, but the events of the past fortnight have upset calculations and thrust the industries into a condition of chaos. It will require not only a superhuman effort on the part of the manufacturers, but also the co-operative good will of the workmen to repair the damage and once again set the wheels of industry on the highway to sustained prosperity.

Iron and Steel Markets.

Business on the iron and steel markets is virtually at a standstill. Production has almost ceased, only two blast-furnaces in this district having been kept in operation, and consequently any iron consumed must come out of

stock. A little iron is being used by the foundries that are working, and a few small parcels have been sold to the Continent for shipment when facilities offer. That, however, is the extent of the business done, and what will happen when the miners restart is largely a matter for speculation. In any case, fuel seems likely to be dearer, and as it may be some time before the blast-furnaces can produce marketable iron, there may be a period during which stocks will have to be drawn upon. With these points in view, the makers of Cleveland pig iron are not very keen sellers, and nominally at least they have advanced quotations 2s. 6d. per ton. Thus, for home consumption No. 3 G.M.B. Cleveland pig iron becomes 72s. 6d. per ton, No. 1 foundry 76s., No. 4 forge 71s., and in each case 6d. more is asked for export iron, though little export business can be hoped for at such prices. There are still big stocks of hematite, but makers take a firmer stand, and mixed numbers are quoted at 77s., with No. 1 quality at 77s. 6d. There is no market for foreign ore, but best Rubio ore is nominally 21s. 6d. per ton c.i.f. Tees. Such business as is being done in the manufactured iron and steel trade is at pre-strike figures.

The Coal Trade.

Pending a settlement with the miners, coal operations on the Northern markets are at a standstill. However favourable a turn the deliberations going on between the owners and miners may take, there will be little chance of getting the pits started before the middle of next week. It is not unlikely that June will be here before a full resumption is made. There are 75 pits idle in Northumberland, with 60,000 men unemployed, besides 200 pits and 150,000 idle miners in Durham, a total of 275 collieries and 210,000 workers idle in these counties. It is generally recognised that the primary issue is concerned with the percentage to be added to the basis wages and the length of the working shift. Those who have to find markets abroad for coal are aware of the economic verities. Wages are the chief factor in determining at what price the product can be offered, and if the price is not equal to meeting that of competitive rivals, the orders go elsewhere. In the present dislocation customers on the Continent have not been inconvenienced, because they had other sources of supply, and what has been lost to Great Britain has been a gain to America, Germany, Silesia, and other countries with coal to sell. Orders for export are not likely to materialise for some time, and the only hope of the trade appears to lie in replenishing the depleted stocks of large utility companies. Forward prices are unobtainable. The coke branch is idle, as there are no available stocks for export. Here, again, forward prices are not indicated.

SCOTLAND.

(From our own Correspondent.)

Before and After.

At the end of April the position in the industrial world became tense, but few anticipated the events which followed. A coal strike seemed inevitable, but anything beyond that was outwith the anticipation of most men. A better feeling appeared to exist in certain circles, owing to improved conditions at the shipbuilding yards, and the hope of further contracts in the near future, when the industrial horizon was clear of the coal trouble, the possibility of which was blamed for retarding business. The events of the past days have played havoc with many hopeful signs of business. Some may survive, but many orders are hopelessly lost. Meanwhile many are engaged taking stock and reviewing the situation. Work is being resumed gradually, but there are still instances of idleness pending an adjustment of agreements for future conduct. Even allowing for an early restart in the coal industry, a considerable loss of time must still be faced before final adjustments and reconciliations take place in other branches of industry. Meanwhile, though the air has been cleared, the steel, iron and coal markets are practically without movement.

Iron.

The employers in many instances are seeking a guarantee against any repetition of a breach of contract, and those in the iron trade are no exceptions to this rule. The President of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board has intimated to the operatives' secretary that employers are prepared to resume work, so far as fuel and other conditions permit, without alteration to wages or conditions, provided a guarantee is given that in future the rules of the Board will be observed and no repetition of the breach will take place. The operatives' secretary is unable to give such guarantee, and a meeting of the Board will therefore be necessary before work can be resumed.

Coal.

It has been said that the supplies of coal in this district are comparatively good. At a large number of collieries considerable stocks are available if transport can be arranged. Meanwhile, most municipal concerns are well off for supplies, while household requirements are diminishing as the season advances. Until fuel moves freely, however, markets are likely to be more or less stagnant. Some, if not many, industrial concerns have, owing to the general state of trade, only been buying immediate supplies of fuel, and the probability is that many will require to remain closed until fuel is again procurable in sufficient quantity.

Scottish Miners.

During a two days' conference, the Union of Scottish Mine Workers decided to send a full representation of delegates to this week's meeting of the Miners' Federation, with instructions to hold out for satisfactory terms of settlement.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Strike and the Outlook.

THE general strike completely overshadowed the miners' dispute, but though the former is at an end, the chief source of anxiety for South Wales still remains, as it is one of the principal coal-exporting centres in the country and the industry is at a standstill. While complete inactivity prevails at the pits, and business is idle, coalowners and exporters have the mortification of seeing brisk operations being carried on for American and German coals, especially the latter, and the more business that is done in those coals the less chance is there of recovering the markets abroad. So far, there is next to no inquiry for Welsh steam coals for delivery when work is resumed at the pits in this district, so that, unfortunately, orders will be very scarce for some little time after the pits are opened. There is so much uncertainty as to what the conditions of work will be, and at what prices coal can be sold, that exporters prefer to wait, while foreign buyers appear to be not in the least anxious about supplies. As to when a resumption of work will take place it is difficult to form any definite idea, but the general feeling is that no restart can be made before next Monday week, viz., the last day of this month, as the belief prevails that no agreement will be come to this week, and there is the distinct probability that the miners' leaders will eventually submit the proposals for a settlement to the workmen, which will mean a ballot of the miners. So far as can be seen, neither the coalowners nor the miners' leaders are enamoured with the proposals of the Prime Minister, and it would not create very much surprise if the employers and the representatives of the miners got to grips and settled the terms themselves.

Strike Effects.

Considering the critical times which have been passed through, it must be said that South Wales has come out of it extremely well. It has been a surprise that such good order was maintained. Transport arrangements for food supplies and other essential commodities worked wonderfully well, considering the extent of the suspension of normal facilities. Coal shipments, of course, came to a standstill, and work at iron and steel and tin-plate works was considerably curtailed. All the docks, of course, presented a very dismal and depressing appearance, inasmuch as, in addition to the stoppage of coal shipments, discharging operations on most steamers with cargoes of iron ore and pitwood, &c., were held up, though by volunteer labour ships with food supplies were able to be discharged. Work in the ship-repairing industry has been at a very low ebb, and will be for some time, as there is an absence of tonnage requiring attention. Ships have been diverted to other trades, and it will probably be a few weeks before normal supplies will come to this Channel, and then only provided there is a settlement shortly of the miners' dispute. The only section of the workers in the ship-repairing industry which was out in obedience to the call for a general strike was that comprising the labourers, who are members of the Transport Workers' Federation, but their action did not greatly affect the position, as there was not very much work available for them and employers carried on without them. There has, in fact, been more trouble with the workmen since the general strike was called off than there was previously, and the question which has been most at issue has been that of reinstatement. The railwaymen did not go back to work for a day or two after the termination of the general strike, and many of them are, of course, still idle, inasmuch as there is very little work for them as yet, with coal shipments at a standstill and the train services considerably short of the normal. At Cardiff the dockers were back at work on Monday, for such work as was available in the discharging line, except that the men engaged in the discharging of pitwood did not resume. Pitwood importers raised the question of a reduction in the minimum wage, but the men's leaders contended that this was a violation of the national agreement, and as the result of a meeting of the parties on Tuesday morning the old terms were maintained by agreement, and it was arranged that there should be a recommencement of work on Wednesday. Tug-boat owners also agreed with their men to take them on again on the old terms, with the clause "as and when required," but instead of the owners running their boats separately, they have arranged to pool the service until trade revives, and the demand for tugs is more active. Four tugs for the present will be in commission, while about a score will be temporarily laid up. At Newport the transport workers are not yet back at work, and so far they decline to resume until the Corporation tramways agree to reinstate the whole of their employees. The Corporation is standing by its decision to employ permanently a number of men who offered their services when the general strike was called, and this, of course, means that a number of the old workmen are for the time being displaced. Settled conditions have not been reached at Swansea, and up to Wednesday there was no work at the docks.

LATER.

Newport dock workers decided late on Tuesday night to resume work on Wednesday. At Swansea there is little employment for those men who decided to work. The dock workers in the service of the Great Western Railway at Swansea who had declined to accept the company's terms were idle on Wednesday morning, but it was expected that they would fall into line before long. The only tin-plate works in the Swansea district that have been able to resume work are the Morriston and Midland and the Beaufort at Morriston and Messrs Gilbertson's works at Pontardawe. Steel works have been unable to re-start owing to shortage of coal supplies. It is estimated that the stoppage of work has meant the loss of ship-repairing work valued at £15,000 in the Swansea district alone. At Cardiff there has been a hitch in the settlement concerning tugboatmen, who are insisting on the owners putting eight boats into commission instead of four out of twenty-eight.

Coal Trade.

Immediately the strike commenced steps were taken for the conservation of all supplies of coal, having regard to the requirements of essential services, such as food works, public utility undertakings, &c., and arrangements were made that all coal or patent fuel must be purchased under a form prescribed by the Coal Emergency Committee. Prices were agreed upon as follows:—Large coal, 25s.; through coal, 20s.; small, 15s.; washed cobbles, 25s.; nuts, 22s. 6d.; peas and beans, 21s. 6d.; washed and unwashed duff, 15s.; patent fuel, at works, 25s. These prices applied to coals that were standing, and were voluntarily agreed to by the colliery companies and owners of patent fuel works. According to Mr. Finlay Gibson, the secretary to the Coal Emergency Committee, there is a sufficient supply of coal and patent fuel available to meet the requirements of the public for some considerable time, and the coal dealers are able to continue their business without interruption, as when coal cannot be obtained patent fuel can be purchased. The position in the country districts is now under consideration, and it is hoped to make arrangements within the next few days to supply limited quantities to these areas.

LATER.

The South Wales coalowners have decided that the following maximum prices shall be fixed for various descriptions of coal required for industrial purposes:—Swansea steam and bituminous coals: Large, 25s. per ton; cobbles and nuts, 27s. 6d. per ton; peas and beans, 22s. 6d. per ton; through coal, 20s. per ton; Swansea dry smalls, 14s. per ton; Swansea bituminous smalls, 17s. per ton. In the case of anthracite coals the maximum prices are to be those ruling on April 1st last. The prices are for coal in wagon where the latter stands and the purchaser will pay all railway charges, &c., from such place to the final destination.

IRON AND STEEL INSTITUTE: ANNUAL MEETING.—The President has decided that the postponed annual meeting of the Iron and Steel Institute shall take place on Thursday and Friday, June 3rd and 4th. The meeting will be held, as usual, in the Rooms of the Institution of Civil Engineers, Great George-street, London, S.W. 1. The programme of the meeting as circulated on April 8th will be adhered to as nearly as possible. The annual dinner, which, in view of the present situation, may now necessarily be of an informal character, will take place at the Connaught Rooms (Prince's Room) on Thursday evening, June 3rd, at 7 for 7.30 p.m. All dinner tickets previously issued will be available.

PRESENTATIONS FOR LONG SERVICE.—On May 1st an interesting ceremony was performed at the works of Lumbys, Ltd., of Halifax. It consisted of the making of presentations to four servants of the firm, the aggregate of whose services with the company extended to 200 years. The gathering was nominally called in order that Mr. S. Naylor, the managing director of the firm, might be presented with a smokers' cabinet for himself and a coffee service for Mrs. Naylor, subscribed for by the employees and staff to mark the occasion of his completing fifty years' service with the firm, into the employment of which he had originally entered as office boy. After the presentation and, of course, speeches, Mr. Naylor sprang a surprise on the meeting by presenting, on behalf of the firm, a wallet containing £50 to each of the three following employees, who were all in their fiftieth year of service:—Messrs. James Hayward, Tom Collins and W. Barrett.

THE ROYAL METAL TRADES PENSION AND BENEVOLENT SOCIETY: SEVENTY-EIGHTH ANNIVERSARY FESTIVAL.—The Lord Mayor of London—Sir William Robert Pryke—and the Board of Management of the Royal Metal Trades Pension and Benevolent Society, have come to a decision that, in view of the industrial situation, it will not be in the best interests of the Society to hold the seventy-eighth anniversary Festival, which, as previously announced, it was intended should be celebrated on June 1st. The propaganda which, during the present month, should have developed intensively, has had to be held up, and consequently the benefit which it was anticipated would accrue has not materialised. His Royal Highness the Prince of Wales fully appreciates the position and agrees that the best course is a postponement until a date later in the year, when he has graciously promised to attend. Immediate notification will be given when a new date has been arranged.

ENGINEERING GOLFING SOCIETY.—The Spring Meeting of the Engineering Golfing Society was held, in fine weather, on the course of the Beaconsfield Golf Club on Thursday, April 29th. In the morning there was an 18-hole medal round, and the President's Cup and Memento in the First Division were won by Mr. J. R. Dallmeyer, with a score of 84 — 6 = 78, the second prize going to Mr. E. R. Peal with 88 — 9 = 79. In the Second Division the Wilson Cup and Memento were won by Mr. W. R. Manning with 95 — 15 = 80, the second prize being taken by Mr. H. P. Gaze with 100 — 17 = 83. The Scratch Prize, presented by the Captain, was won by Mr. D. B. Mansergh, with a score of 76, and an additional Scratch Prize was given to Mr. W. R. Manning for his 95. In the afternoon there was an 18-hole round, foursomes against bogey, when the Timmis Cups and Mementoes—which were played for for the first time—were won by Messrs. W. L. and D. B. Mansergh, with 3 up, the second prizes being taken by Messrs. G. M. Gill and L. Trewby.

VICKERS GROUP AMATEUR OPERATIC SOCIETY.—On April the 29th and 30th, and May 1st, the Vickers Group Amateur Operatic Society gave performances of the opera "Tom Jones," at the New Scala Theatre. We had the good fortune to be present on the first evening, and we witnessed a really admirable display which reflected the highest credit on all who had been concerned in its preparation. Though, as is nearly always the case with an amateur society, the acting of all the characters was not equally good, yet the general average was extraordinarily high, and some of the singing was exceptionally fine. We have not space to comment upon the acting of individual characters: it would be too formidable a task seeing that there were no fewer than twenty-nine names in the cast, but we can say without hesitation that it was quite the best presentation that we have seen the Society give. A word of special commendation must be said of the chorus, which had been very well trained, not only in singing, but in action as well. The choruses were delightfully rendered, and the various evolutions were carried out with unanimity and rhythm. The music was provided by a kindred society, the Vickers Westminster Orchestra, which acquitted itself with even greater success than on the other occasions on which we have listened to it. During the choruses it was splendid, but, if we may venture to offer one criticism, it is that during some of the solos, the loudness of the music—despite the manifest efforts of the energetic conductor—tended to drown the voices of the singers, some of whom were not quite accustomed to throwing their voices out into such a large auditorium as that of the Scala Theatre. That criticism apart, however, the whole play was a great success, and we, together, we should say, with the whole of the audience—which was large—spent a most enjoyable evening.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	18/- to 21/-
(1) Spanish	18/- to 21/-
(1) N. African	18/- to 21/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0 to 4 1 6	
No. 3 Foundry	3 16 6 to 3 19 0	
N.E. COAST—		
Hematite Mixed Nos.	3 17 0	3 17 0
No. 1	3 17 6	3 17 6
Cleveland—		
No. 1	3 16 0	3 16 6
Silicious Iron	3 16 0	3 16 6
No. 3 G.M.B.	3 12 6	3 12 6
No. 4 Foundry	3 11 6	3 12 0
No. 4 Forge	3 10 6	3 11 0
Mottled	3 10 0	3 10 6
White	3 10 0	3 10 6
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 3 0 to 3 4 0	
,, Forge	2 15 0 to 2 16 0	
(3) Derbyshire—		
No. 3 Foundry	3 6 0 to 3 7 0	
Forge	3 0 0 to 3 2 0	
(3) Lincolnshire—		
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 7 6 (a) / 4 10 0 (b) / 4 15 0 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	11 5 0	11 0 0
Best	—	—
N.E. COAST—		
Common Bars	11 0 0	—
LANCS.—		
Crown Bars	11 0 0	—
Second Quality Bars	9 15 0	—
Hoops	14 0 0	—
S. YORKS.—		
Crown Bars	12 10 0	—
Best Bars	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	11 0 0 to 11 10 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 10 10 0	
Gas Tube Strip	12 5 0 to 12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	11 0 0	—
Ship Plates, ¾in. and up	7 12 6	7 0 0
Sections	7 2 6	6 5 0
Steel Sheets, under 3/16in. to ¼in.	8 15 0 to 9 5 0	
Sheets (Gal. Cor. 24 B.G.)	—	£15 7 6 to £16 10s.

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	7 12 6	—
Angles	7 2 6	—
Boiler Plates	11 10 0	—
Joists	7 2 6	—
Heavy Rails	8 0 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 0 0†	—
Light Rails	8 5 0 to 8 10 0	
Billets	7 10 0 to 9 0 0†	
MANCHESTER—		
Bars (Round)	8 0 0 to 8 5 0	
,, (others)	8 0 0 to 8 5 0	
Hoops (Best)	13 5 0	13 0 0
,, (Soft Steel)	10 0 0	9 15 0
Plates	7 17 6	—
,, (Lancs. Boiler)	11 10 0	—
SHEFFIELD—		
Siemens Acid Billets	10 10 0	—
Bessemer Billets	11 5 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 2 6	—
Soft Basic	6 15 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
MIDLANDS—		
Small Rolled Bars	7 15 0 to 8 0 0	
Billets and Sheet Bars	6 2 6	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 5 0 to 15 10 0	
Angles	7 2 6	—
Joists	7 2 6	—
Tees	8 2 6	—
Bridge and Tank Plates	7 17 6	—
Boiler Plates	11 0 0 to 11 10 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	19/3 to 19/6
Block Tin (cash)	268 15 0
,, (three months)	265 5 0
Copper (cash)	56 10 0
,, (three months)	57 7 6
Spanish Lead (cash)	28 10 0
,, (three months)	29 0 0
Spelter (cash)	32 3 9
,, (three months)	32 12 6
MANCHESTER—	
Copper, Best Selected Ingots	61 15 0
,, Electrolytic	65 5 0
,, Strong Sheets	90 0 0
,, Tubes (Basis Price)	0 1 0½
Brass Tubes (Basis Price)	0 0 11½
,, Condenser	0 1 2
Lead, English	30 15 0
,, Foreign	29 7 6
Spelter	33 0 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/- per lb.	
Ferro Tungsten	1/9d. per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 10 0	7/6
,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/3
,, 8 p.c. to 10 p.c. ,,	£20 15 0	6/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£38 10 0	12/6
,, ,, 1 p.c. ,,	£44 10 0	15/-
,, ,, 0·70 p.c. carbon	£54 10 0	17/6
,, ,, carbon free	1/5½d. per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 15 0	scale 5/- per unit
,, ,, 75 p.c.	£20 10 0	scale 6/- per unit
,, Vanadium	14/6 per lb.	
,, Molybdenum	6/- per lb.	
,, Titanium (carbon free)	0/11 per lb.	
Nickel (per ton)	£170	
Cobalt	10/- per lb.	
Aluminium (per ton)	£112	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	15/9
,, ,, Ell	16/6
,, ,, Splint	16/6 to 17/-
,, ,, Trebles	15/9
,, ,, Doubles	14/- to 14/6
,, ,, Singles	13/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9
,, ,, Jewel	17/- to 17/6
,, ,, Trebles	17/-
FIFESHIRE—	
(f.o.b. Methil or Burnt-island)—Steam	12/6 to 14/9
Screened Navigation	21/-
Trebles	14/- to 15/-
Doubles	14/-
Singles	13/- to 13/6
LOTHIANS	
(f.o.b. Leith)—Best Steam	14/- to 14/3
Secondary Steam	13/6
Trebles	14/6 to 14/9
Doubles	13/6
Singles	13/6

ENGLAND.

	Export.
(8) N.W. COAST—	
Steams	23/-
Household	40/- to 48/-
Coke	24/-
NORTHUMBERLAND—	
Best Steams	16/-
Second Steams	14/6 to 15/-
Steam Smalls	8/- to 8/6
Unscreened	13/- to 13/6
Household	20/- to 22/-
DURHAM—	
Best Gas	18/6 to 19/-
Second	15/- to 15/6
Household	20/- to 22/-
Foundry Coke	18/- to 20/-

SHEFFIELD	Inland.	
Best Hand-picked Branch	31/- to 34/-	—
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	26/- to 28/-	—
,, ,, House	24/- to 25/-	—
,, ,, Large Nuts	17/- to 20/-	—
,, ,, Small	12/6 to 14/-	—
Yorkshire Hards	17/- to 19/6	—
Derbyshire Hards	16/- to 19/-	—
Rough Slacks	10/- to 12/6	—
Nutty Slacks	7/6 to 9/-	—
Smalls	3/6 to 6/-	—
Blast-furnace Coke (Inland)*	—	—
,, ,, (Export)	f.o.b.	16/- to 17/-

(9) SOUTH WALES.

(*All prices nominal.*)

CARDIFF—	
Steam Coals:	
Best Smokeless Large	26/- to 27/-
Second ,, ,,	24/6 to 25/6
Best Dry Large	24/- to 25/-
Ordinary Dry Large	21/- to 22/-
Best Black Vein Large	25/6 to 26/-
Western Valley Large	24/6 to 25/-
Best Eastern Valley Large	24/- to 25/-
Ordinary ,, ,,	23/6 to 24/-
Best Steam Smalls	17/- to 18/-
Ordinary ,,	16/- to 17/-
Washed Nuts	19/- to 26/-
No. 3 Rhondda Large	26/6 to 27/-
,, ,, Smalls	18/- to 18/6
No. 2 ,, Large	24/- to 25/-
,, ,, Through	20/- to 21/-
,, ,, Smalls	15/- to 16/-
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	22/- to 24/-
Pitwood (ex ship)	26/- to 26/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	39/- to 40/-
Seconds	32/6 to 35/-
Red Vein	27/- to 29/-
Machine-made Cobbles	47/6 to 50/-
Nuts	47/6 to 50/-
Beans	42/6 to 44/-
Peas	23/- to 25/-
Breaker Duff	7/6 to 8/-
Rubbly Culm	12/6 to 13/6
Steam Coals:	
Large	22/6 to 24/6
Seconds	20/- to 22/-
Smalls	11/- to 15/-
Cargo Through	16/6 to 17/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market 17/6 to 19/- at ovens. † Latest quotations available. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

The Rail Union.

THE signing of the Rail Union agreement is being held up through a difficulty in coming to an understanding with the British makers over the exclusion of the Dominions from the British home market. Under the old Union the Dominions were regarded as a home market for British rail firms, whose participation in foreign orders was independent of the business they did with them, but continental makers now claim that orders from the Dominions should be included in the British percentage of foreign trade. They argue that as rails are now supplied to the Dominions by German, Luxemburg and French makers, they can no longer be deemed an essentially British market, and continental firms declare that they cannot allow themselves to be placed in a less favourable position in those markets than the British. This is one of the difficulties that will constantly arise over international agreements in view of the undermining of British foreign and colonial trade by the currency depreciation abroad. It is stated that there is some hope of an early settlement, although it is difficult to see how British rail firms can give way over a question which is purely national. Meanwhile, it is reported that the Belgian and Luxemburg makers have not yet settled upon the manner in which their participation is to be split up between them, but it is believed that Belgium will receive 10½ per cent. and Luxemburg 6½ per cent.

Reparations and Public Works.

The method of obtaining reparation from Germany in the form of manufactured goods is by no means satisfactory. It helps the national finances, but it causes a serious prejudice to home industries, and the considerable orders placed in Germany have aroused strong opposition from wagon builders, agricultural machinery makers and other firms which are particularly affected by this new form of competition. The Government has therefore become very chary about ordering manufactured goods from Germany on account of reparations. The Minister of Public Works is even endeavouring to revive the project of one of his predecessors, M. Le Trocquer, who wanted to utilise the reparations for carrying out a vast scheme of public works which could not be put in hand in the present state of the country's finances. The Germans at that time replied that they were quite prepared to supply everything necessary for reconstruction in the devastated regions, but they did not regard reparation in the light of developing the economic resources of the country generally. M. de Monzie evidently believes that the operation of the Dawes plan will offer him a better chance of success, for he proposes to utilise the reparations mainly to carry out the scheme of hydro-electric installations, port improvements, inland waterway extensions and railway equipment. At present the hydro-electric plants have a capacity of 1,000,000 kilowatts, and the undertakings in hand will provide another 300,000 or 400,000 kilowatts. The entire scheme will, when completed, embody 4,000,000 kilowatts, and an annual economy of something like 30,000,000 tons of coal is anticipated. In other words, France would be practically independent of foreign supplies of fuel.

Oil Borings.

Of the large number of experimental borings that have been carried out in France during the past few years, the only prospecting work which has given encouraging results is that accomplished in the commune of Gabian in the department of Hérault. The area to be prospected was designated by geological experts appointed by the Government to investigate the possible sources of oil supply, and when a first bore, early in 1924, produced petroleum the work was continued until, in all, ten borings were made. Four of them had to be abandoned on account of water, three have not yet been terminated, and three others are producing oil. In 1924 the first well gave 222 cubic metres and the following year 697 cubic metres. Another well produced 1400 cubic metres in 1925, and from the beginning of the present year to April 1st the two wells gave 46 cubic metres and 1255 cubic metres respectively. Altogether, about 2300 tons of oil have been supplied by the wells. A little while back a delegation from the Office National des Combustibles Liquides visited Gabian, and the result of the inspection appears to have been that, while satisfied with the results obtained, the experts recognise that the borings now in progress must be terminated before any pronouncement is possible upon the commercial value of the new oilfield.

Tank Steamer.

One phase of the oil propaganda being carried out in this country is to encourage the construction of tank steamers, and particular interest is therefore taken in the motor tanker just launched at Bordeaux for an American firm. Built by the Chantiers et Ateliers de la Gironde and known as the Général-Gassouin, the steamer is fitted with fourteen vertical cylindrical tanks arranged in two rows, while four other tanks are placed fore and aft, the idea being to allow of the transport of oils of different qualities. The new tanker has a length of 117 m., a width of 17 m., and draws 8.45 m. of water. Its propelling machinery consists of a Diesel-Sulzer engine developing 1850 horse-power at 90 revolutions per minute.

Pig Iron Production.

The pig iron production during March amounted to 772,416 tons, which is the highest monthly figure yet recorded. The number of furnaces in blast was 147. The output of raw steel totalled 725,611 tons, an increase of 95,000 tons on the previous month. This remarkable expansion is due entirely to the export demand following upon the depreciation of the franc, and as the demand is more or less speculative, it is necessarily precarious, for should the margin of cost in favour of blast-furnace proprietors be lost in the heavier charges and advancing prices, the situation may become less satisfactory.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

249,586. November 25th, 1924.—COMBUSTION CHAMBERS, G. M. Blackstone, F. Carter and E. Carter, Rutland Engineering Works, Stamford, Lincoln.

This specification starts with a dissertation on the proper positioning of the fuel injection valves of high-compression oil engines, and goes on to make a claim in which the explosion

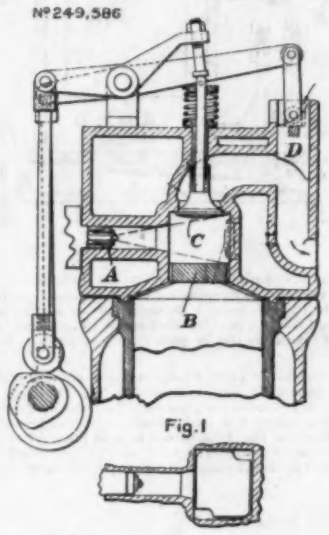


Fig. 1

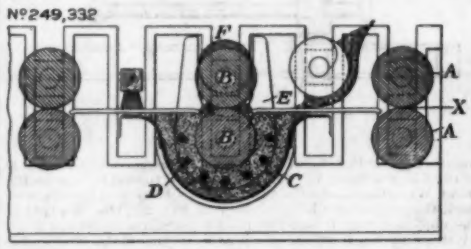
Fig. 2

chamber is stipulated as being of approximately cubical form, with an extended cavity on one side for the accommodation of the injection valve A. The bottom of the explosion chamber is formed by the extension B of the piston, which is formed, in plan, as shown in Fig. 2. The exhaust valve is shown at C, and is used alternatively as the air admission valve, with the assistance of the transfer valve D.—*March 25th*, 1926.

MACHINE TOOLS AND SHOP APPLIANCES.

249,332. April 9th, 1925.—SCOURING TIN-PLATES, Richard Thomas and Co., Ltd., Bush House, Aldwych, London, W.C. 2, and E. A. Jones, South Wales Works, Llanelly, Carmarthen.

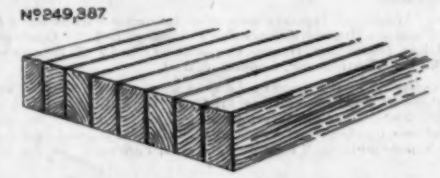
This invention is put forward with the object of preventing the bran used in cleaning, or scouring, tin-plates from becoming



caked, with the result that it loses its effectiveness. The scouring machine is, in general, more or less normal and the tin-plate X is fed in between a pair of rolls A A to pass between the scouring rolls B B in a bath of bran C. Within the bran container there is a set of angular bars D D mounted in end plates E, which are rocked by the excentric F and consequently agitate the bran and so prevent its caking.—*March 25th*, 1926.

249,387. July 20th, 1925.—DROP HAMMER BOARDS, The Detroit Drop Hammer Board Company, 3826, Grand River-avenue, Detroit, Michigan, and R. T. Teakle, 70, Virginia-park, Detroit.

The inventors propose to make the boards used for raising the

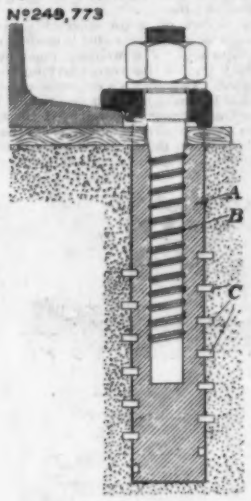


tups of drop hammers of a series of bars of wood interleaved with leather and glued together, as shown in the illustration.—*March 25th*, 1926.

TRAMWAYS AND RAILWAYS.

249,773. November 16th, 1925.—SCREW SPIKES FOR CONCRETE SLEEPERS, E. F. L. Vagneux, 15, Rue de Château, Dijon (Côte-d'Or), France.

The essential feature of this invention is that the wooden plug A which is used to hold the bolt B is an easy fit in the hole in the concrete sleeper. The intervening space is filled with an adhesive waterproof substance, which provides a certain degree of

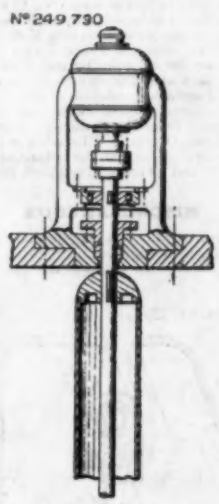


electrical insulation. The plug is held in the sleeper by a helical dowel C, which is cast in place and fits a previously cut groove in the plug.—*April 1st*, 1926.

SHIPS AND BOATS.

249,730. July 31st, 1925.—SHIP'S RUDDERS, W. Roos, 651, West 178th-street, New York.

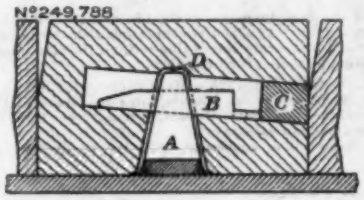
The inventor proposes to use the Magnus effect for the steering of ships, and for this purpose mounts a vertical roller at each end of the ship. These rollers are driven by electric motors, as



shown in the drawing, and the motors are supplied with current through a rheostat on the bridge. The rheostat is connected with the steering wheel, and is used to vary the speed and direction of rotation of the rollers in order to steer the ship.—*April 1st*, 1926.

249,788. December 31st, 1925.—DECK PLANKING, W. Neisener, Elisabethstrasse 60 III., Kiel-Gaarden, Germany.

In order to overcome the objection to the usual method of fixing wooden planking to the metal decks of ships, which objection is that rusting of the bolts ultimately leads to leakage, the inventor secures the planks by means of bosses welded to the



deck. Several alternative fastenings are described. In that illustrated an eye-bolt A is welded to the deck and the plank is secured by the hidden wedge B, which, in turn, is held in place by the plug C. A projection D is provided on the eye-bolt to mark the plank, so that the recesses can be machined out at the proper spacing after the bolts have been welded in place.—*April 1st*, 1926.

LIGHTING AND HEATING.

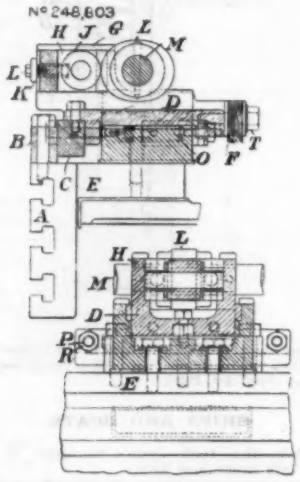
249,796. February 27th, 1926.—ELECTRIC LAMPS, *The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C. 2.*

In this specification a claim is made for "a method of manufacturing electric lamps with light-diffusing or coloured bulbs, according to which the internal wall of a clear glass bulb is sprayed or coated with a suspension of inorganic material in water or alcohol, which, when the suspension medium has evaporated, leaves a translucent diffusing or coloured layer as residue." It is suggested that a suspension of kaolin and water glass is very suitable for the purpose.—*April 1st*, 1926.

WELDING.

248,803. June 11th, 1925.—IMPROVEMENTS IN ELECTRIC RESISTANCE WELDING MACHINES, Walter Clifford Priestley, of Proswell Engineering and Welder Company, Ltd., of 177, Thornton-road, Bradford.

The secondary circuit of a transformer supplying electric current to resistance welding electrodes is made and broken at a predetermined frequency. The welding machine has a face-plate A upon which one of the arms carrying the usual roller electrode is mounted. This forms a convenient point of attachment for a contact B through which the return circuit of the secondary of the transformer is completed through the other roller electrode on a second arm insulated from the first arm and through the work between them. A robust contact C normally bears against the contact B and is mounted upon a slide D moving

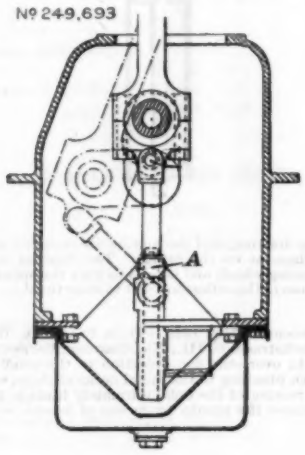


in guides mounted upon and insulated from the frame E of the machine integral with the face-plate A. The movable slide D has a clamp in which one end F of the secondary windings can be secured. This slide D is also connected to a yoke G in which a freely sliding block H is mounted, and it carries a roller J in insulated bushes. A compression spring K is arranged between the insulated bearings for the roller J and the fixed yoke G and its tension can be adjusted by means of a screw L. The roller J makes contact with a double-throw cam L pinned to the driving shaft M. For each revolution of the driving shaft M the roller J can freely move inwards twice, and the contact C will be drawn away twice from the stationary contact B by reason of the tension springs O arranged between it and the frame E. The tension of each spring can be adjusted by means of a threaded spindle P and locknut R.—*March 25th*, 1926.

MISCELLANEOUS.

249,693. April 29th, 1925.—BALANCING PISTONS, Sir H. Austin, Lickey Grange, Broomagrove.

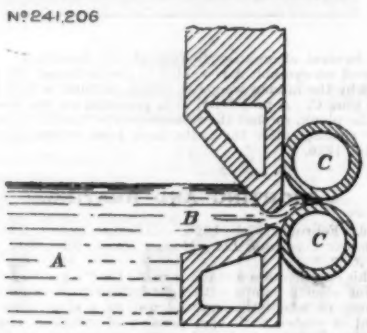
The inventor proposes to balance the kinetic effect of the



piston of an engine by means of what is virtually a dumb piston, or "bob-weight," A, which is connected with the main crank, by means of a separate connecting-rod, on the side opposite to the working piston.—*April 1st*, 1926.

241,206. October 8th, 1925.—MANUFACTURE OF SHEET GLASS, Société Anonyme des Manufactures des Glaces et Produits Chemiques de Saint-Gobain, Chauny et Cirey, 1 bis Place des Saussaies, Paris.

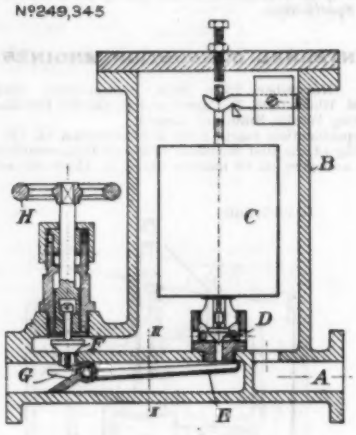
This invention is concerned with the production of glass



with a patterned face and aims at the maintenance of the upper surface of the glass at such a temperature that the pattern is easily impressed thereupon. For his reason the glass is taken from the pot A, through an opening B, and is drawn forward by a pair of rolls C C, which are so arranged that their mean position is above the centre of the opening. In this way the upper surface of the glass is subjected to a minimum amount of cooling before it is flattened by the rolls. The lips of the opening B are hollow, as shown, so that they may be readily heated.—*April 1st*, 1926.

249,345. April 25th, 1925.—STEAM TRAPS, H. Rohonci, 19, Fóthi ut, Budapest VI., Hungary, and J. Godra, 21, Bulcsu utca, Budapest VI.

This is a form of quick-discharge steam trap, which is connected with the range it is desired to drain by the branch A.



When water accumulates in the chamber B the float C rises and opens the valve D. The escaping water impinges on the blade E and lifts the by-pass valve F by means of the arm G, so that the accumulated water is rapidly discharged. The wheel H provides a means of operating the by-pass valve manually.—*March 25th*, 1926.

249,783. December 14th, 1925.—A TOOL FOR HOOPING CASES, A. Lambotte, 43, Rue de Bruxelles, Esneux, Belgium.

This tool is intended for straining the hoop iron used to reinforce packing cases. One end of the hoop is first provided with a clip—as shown in Fig. 1—which is held in place by turning over the end A—see Fig. 2. The band is then put round the box, the other end is also threaded through the clip at B, through the

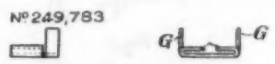


Fig. 1.

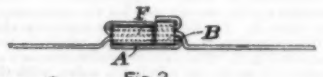


Fig 2

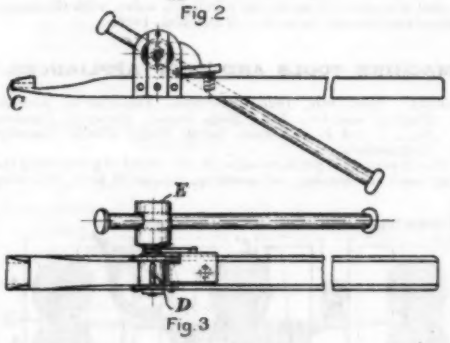


Fig. 3

mouth C—see Fig. 3—of the tool, and engaged in the slot D of the winding drum E. The drum is then turned to tighten the band. When the band is tight the whole tool is turned over to bend back the strip over the clip—see F in Fig. 2. The ears G G of the clip—see Fig. 1—are hammered down, the band is cut off by straining it against the sharp edge of the tool. The end is then clinched over as shown in Fig. 2.—*April 1st*, 1926.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. C. PETERSEN has been appointed Metropolitan-Vickers London district manager, in succession to Mr. P. F. Crinks, who is now managing director of the Metro-Vick Supplies Company.

THE HARVIE CORPORATION, Ltd., of Broadway Buildings, Westminster, London, S.W. 1, asks us to announce that it has organised its activities for the sale of machinery into a separate department.

MR. ALBERT H. HUGHES asks us to announce that he has left the Paterson-Hughes Engineering Company, Ltd., of Glasgow, and has joined the Harvie Corporation, Ltd., of Broadway Buildings, Westminster, London, S.W. 1.

INSTITUTE OF PATENTEES asks us to announce that it has changed its head offices from 44, Great Russell-street, W.C. 1, to 39, Victoria-street, Westminster, London, S.W. 1. Its new telephone numbers are Victoria 4222 and 4223, and its new telegraphic address, "Patentees, Sowest, London."

A GOOD OIL CAN.—We have received from Joseph Kaye and Sons, Ltd., Lock Works, Leeds, a sample of their latest oil cans. Like all their products, it is a really substantial affair that should stand all the ordinary knocking about of a machine shop. It is of the familiar force-feed type, and differs only in that it has a detachable spout retained in position by a long gland nut and made tight against a leather washer. So far, the makers inform us, they are stocking only the half pint size in this form. The Admiralty, we are told, has already placed large orders for these new cans with interchangeable spouts.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TUESDAY, MAY 25TH

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Organic Theories of Oil Origin," by Mr. Ernest Clark. 5.30 p.m.

THURSDAY, MAY 27TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Annual general meeting of corporate members and associates. 6 p.m.

ROYAL AERONAUTICAL SOCIETY.—7, Albemarle-street, London, W. 1. Wilbur Wright Memorial Lecture. "Sustentation in Flight," by Mr. F. W. Lanchester. 6.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. "The Corrosion of Metals," by Mr. Ulick R. Evans. 5.15 p.m.

FRIDAY, MAY 28TH.

CHEMICAL ENGINEERING GROUP.—Abbey House, Westminster, London, S.W. 1. Annual general meeting. 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "Aims and Methods of Therapeutic Research," by Sir Almroth Wright. 9 p.m.

TUESDAY, JUNE 1ST.

SOCIETY OF GLASS TECHNOLOGY.—University College, Gower-street, London, W.C. 1. Demonstration and lecture, "Glass in Early Ages," by Sir W. M. Flinders Petrie. 2.30 p.m. Annual dinner at the Hotel Cecil, Strand, W.C. 2. 7 for 7.15 p.m.

WEDNESDAY, JUNE 2ND.

SOCIETY OF GLASS TECHNOLOGY.—Research Laboratories of the General Electric Company, Ltd., Wembley. Papers: "Opal Glass," by Mr. J. W. Ryde; "The Electrical Conductivity of Glass at High Temperatures," by Mr. F. F. S. Bryson; "The Influence of Moisture on the Rate of Melting and on the Properties of Soda-lime-silica Glasses," by Edith M. Firth, Mr. F. W. Hodkin, Mr. Michael Parkin, and Professor W. E. S. Turner: "The Physical Properties of Zinc Oxide Containing Glasses," by Dr. S. English and Professor W. E. S. Turner. 2.30 p.m. Visit to Osram G.E.C. Glass Works at Wembley. 10.15 a.m.

THURSDAY AND FRIDAY, JUNE 3RD AND 4TH.

IRON AND STEEL INSTITUTE.—Institution of Civil Engineers, Great George street, London, S.W. 1. Annual meetings, deferred from May 6th and 7th, on account of the general strike. For programme see page 447. 10 a.m. each day. Annual dinner at the Connaught Rooms, Great Queen-street, W.C. 2, on Thursday, June 3rd, at 7.30 p.m.

SATURDAY, JUNE 5TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—South-Eastern District meeting at Richmond and Chertsey. 11 a.m.

TUESDAY TO FRIDAY, JUNE 8TH TO 11TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—Summer meeting in the North-Eastern Centre, Newcastle. For programme see page 384.

WEDNESDAY TO SATURDAY, JUNE 9TH TO 12TH.

INSTITUTION OF WATER ENGINEERS.—Summer meeting in Manchester. For programme see page 450.

CONTRACTS.

THE WOODALL-DUCKHAM VERTICAL RETORT AND OVEN CONSTRUCTION COMPANY (1920), Ltd., has received from the Wellington (Salop) Gas Company an order for an installation of continuous working vertical retorts, having a carbonising capacity of 37 tons per day. The plant is to be complete with coal and coke-handling machinery, coke storage hopper for loading into railway trucks, and provision will be made for the installation of a waste heat boiler at a later date.

GRANTS FOR RESEARCH ABROAD.—Two Robert Blair Fellowships of £450 each are being offered by the London County Council to adult students of British nationality. They will enable the holders to go abroad for a year for advanced study or research in scientific and manufacturing processes.

ROYAL INSTITUTION.—The annual meeting of the members of the Royal Institution was held on Saturday afternoon, May 1st, Sir James Crichton-Browne, F.R.S., Treasurer and Vice-president, in the chair. The annual report of the Committee of Visitors for the year 1925, testifying to the continued prosperity and efficient management of the Institution, was read and adopted. The report of the Davy Faraday Research Laboratory Committee was also read. It was announced that sixty-two new members were elected in 1925, and that sixty-three lectures and twenty evening discourses were delivered. The books and pamphlets presented amounted to about 254 volumes, making with 567 volumes—including periodicals bound—purchased by the Managers, a total of 821 volumes added to the library in the year. Thanks were voted to the President, Treasurer and Secretary, to the Committees of Managers and Visitors, and to the Professors for their valuable services to the Instituton during the past year. The following were unanimously elected as officers for the ensuing year:—President, the Duke of Northumberland: treasurer, Sir Arthur Keith: secretary, Sir Robert Robertson. Managers: Sir Harry Baldwin, Sir John Biles, Sir James Crichton-Browne, John Mitchell Bruce, Viscount Chelmsford, Ernest Clarke, W. H. Eccles, Sir Oliver Lodge, Charles H. Merz, Sir Ernest Moon, Sir Edward Pollock, Sir Arthur Schuster, Sir Henry Wood, Sir Almroth Wright, and Sir Alfred Yarrow. Visitors: K. A. Wolfe Barry, James H. Batty, W. A. F. Balfour Browne, Charles Carpenter, Alfred Carpmael, Charles J. P. Cave, A. Chaston Chapman, Alexander F. H. Dick, W. Vaux Graham, Sir Lawrence Jones, Ronald Malcolm, Sir Walter Peacock, Hugh Munro Ross, Frank Coston Taylor, and John Tennant. A general meeting of the members of the Institution was held on Monday afternoon, May 3rd, Sir James Crichton-Browne in the chair. Sir J. J. Thomson was elected Honorary Professor of Natural Philosophy and Sir Ernest Rutherford was elected Professor of Natural Philosophy. Miss Lilian Quartly, Sir Henry Maybury, Mr. W. H. Frizell, Mrs. Samuel Courtauld, the Hon. Sir William F. K. Taylor, Mr. G. M. Clark, Mr. Richard M. N. Dawlings, and Mr. Charles S. Gibson were elected members.